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MOSQUITO BRIGADES

Malaria.
Mosquitoes.

MOSQUITO BRIGADES

AND

HOW TO ORGANISE THEM

BY

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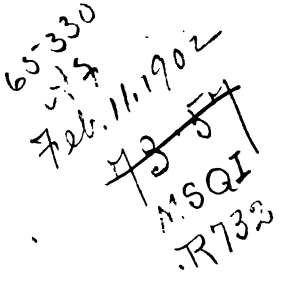

GRATEFULLY DEDICATED

TO

SIR ALFRED L. JONES, K.C.M.G.

AND THE SUBSCRIBERS OF

THE LIVERPOOL SCHOOL OF TROPICAL MEDICINE;

AND ALSO TO

THOSE GENEROUS DONORS

WHO BY THEIR MUNIFICENT SUPPORT

HAVE ENABLED US TO UNDERTAKE

OUR

CAMPAIGN IN WEST AFRICA

PREFACE.

The discovery that the germs of several of the most important tropical diseases, namely, malarial fever, yellow fever, and elephantiasis, are inoculated into human beings by the bites of mosquitoes has revolutionised tropical hygiene. Not only our comfort but our security in the tropics now depends upon the measures we adopt against these insects.

There are several means of protection already well known to us. For example, in India punkahs swing night and day over the heads of Europeans, and at night almost everyone employs mosquito nets. In America entire houses are protected from the invasion of these pests by means of wire-gauze screens fixed to the windows and doors.

Such measures as these, however, have one great defect. They protect only those who can afford them, and who are necessarily few in number. Moreover, it is found in practice that the protection is only partial, because, whatever efforts of this kind we may make, we cannot, especially in the tropics, entirely avoid being bitten.

Another safeguard against mosquito-borne diseases consists in isolating ourselves in buildings separate from the bulk of our neighbours, in the hope that, even if we continue to be bitten by mosquitoes, these insects will not

be infected by having previously bitten infected persons. This means, also, can be adopted only by the rich, and is sometimes very inconvenient even to them.

While all these measures are undoubtedly beneficial, particularly under special circumstances, the question strikes us at once, "Rather than take so much trouble in protecting ourselves from the bites of these insects, would it not be better to get rid of them at once?"

Where this measure can be carried out, not only the rich, but the whole population will be protected; and individuals will be saved the trouble and expense involved in providing their houses with wire-gauze screens.

The object of the present work is to show how we can best wage war against mosquitoes. The information given is based upon experience gained by me during many years' study of mosquitoes in various parts of the world; and more especially upon the actual results of the operations now being carried on by the Liverpool School of Tropical Medicine in West Africa. The work is not written only for medical men in the tropics, but for anyone who lives in countries where mosquitoes abound. I have tried to describe the various operations in detail; and the Appendix contains accounts of the campaigns already started in various parts of the world.

The reader will perceive that, in fact, I am preaching a general crusade of a more novel and perhaps more useful character than most crusades. I trust that he will volunteer under the flag.

LIVERPOOL, 13*th October*, 1901.

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MOSQUITO BRIGADES

THINGS TO BE LEARNT.

1. Leading Facts about Mosquitoes.—As everyone knows, mosquitoes invariably spring from larvæ which live in stagnant water on the ground or in vessels. But mosquitoes are of very many species, which often differ in their habits. Full information on these points will be found in the literature, of which a list is added to this work. It is necessary to record here only a few leading facts.

(1) Mosquitoes are the same as gnats.

(2) All mosquitoes breed in stagnant water.

(3) The kind commonly known as *Culex** carry elephantiasis and yellow fever. They breed generally in vessels of water, cisterns, or drains. They bite sometimes in the day and sometimes at night, according to the species. When they are seated upon the wall their tails hang downwards. Their wings are rarely spotted. Their larvæ when undisturbed float on the surface of the water head downwards; when disturbed they wriggle immediately to the bottom of the vessel which contains them.

---

* A vast number of species of gnats exist, and these species are grouped in a number of genera. *Culex* and *Anopheles* are the commonest genera in most places; but *Culex* has recently been divided into two genera, *Culex* and *Stegomyia*. The latter is the common brindled or tiger mosquito. It carries yellow fever, breeds mostly in vessels of water, and bites much in the daytime. For brevity, I use the word *Culex* in its old sense.

(4) The mosquitoes known as *Anopheles* carry malarial fever. When they are seated on a wall their tails project at an angle outwards. Their larvæ are found mostly in shallow puddles on the ground, in small ponds, in slow and small runnels of water, in pools of rain-water on rocks, on the margin of slow-running streams, and sometimes, but rarely, in vessels of water. These larvæ float flat on the surface of the water like sticks, and move with a peculiar backward skating movement. The *Anopheles* bite mostly at night.

(5) The larvæ of all kinds of gnats require at least six or seven days' life in water before they reach maturity and become winged insects. They cannot withstand thorough drying. Nor can the eggs.

(6) Adult mosquitoes (that is, the winged insects) may live for months even in captivity. They hibernate in cold climates, and can resist severe frost or severe heat. They feed on fruit and leaves, on cattle and birds, as well as on men. As a rule it is only the females which feed on blood.

(7) It is now a matter of the general experience of many investigators, that where mosquitoes abound in a house their larvæ can usually be found at a short distance, say within a few hundred yards from the house. Occasionally, where the house is isolated, and no stagnant water is in its immediate vicinity, mosquitoes may attack it from a greater distance ; but this is exceptional, and in the great majority of cases, especially in towns, almost every house breeds its own mosquitoes in its backyards, or in puddles and drains in the streets close by.

(8) Mosquitoes, especially *Anopheles*, love thick undergrowth.

Further details will be found in the literature already mentioned; but most medical men at least will by this time be quite familiar with such facts.

2. **Some Popular Misconceptions Corrected.**—When the idea of exterminating mosquitoes for preventing malarial fever was first mooted* it was met with considerable opposition, and even ridicule, owing chiefly to various popular misconceptions regarding the matter. People thought that it was proposed to exterminate these insects in whole continents, which would evidently be quite impossible. As a matter of fact the measure was proposed only for towns and certain settlements. Then, again, by the phrase "extermination of mosquitoes" was never meant anything more than their reduction in numbers to an appreciable extent. Even as regards their reduction in number, serious doubts were felt at first, because it was believed that the insects exist in such countless swarms that all measures even to reduce them would be futile. As a matter of fact, however, mosquitoes never exist in countless swarms. To make a rough estimate, I fancy it would be rare to find *on the average* more than twenty mosquitoes to every house, even in the most mosquito-infected districts. These insects, like other animals, have many natural enemies—bats, birds, spiders, and those climatic influences which tend to destroy them or their larvæ. It will indeed be contrary to general experience if these animals do not, as others have done, succumb when they find themselves opposed by a new enemy, and such a formidable one as mankind; that is to say, of course, in special localities where adequates measures are taken against them. As

* In a letter addressed by me to the Government of India, dated February 18th, 1901.

already stated, mosquitoes are known to be rare in certain spots where the conditions are naturally unfavourable to them : all we have to do is to create similar unfavourable conditions by artificial means.

Another popular error is that, even if we succeed in destroying all mosquitoes over a given area, they will swarm in again from the outside immediately after the measures are completed. But it should be clearly understood at once that all measures for the extermination of mosquitoes must be continued indefinitely, so that even if fresh insects do arrive from the outside they will not have an opportunity for multiplying within the given area. In other words, all towns which wish to be kept free from mosquitoes must determine upon, not a single effort, but a continuous one. In fact, just as all towns possess a staff of sweepers for the purpose of keeping its streets clean, so in the future must all towns in the tropics possess a staff of persons whose duty it will be to keep down these dangerous and troublesome pests.

3. General Principles to be Followed.—Suppose it were required to get rid of all mosquitoes from an island situated in mid-ocean. It would be possible to follow two courses. First, we might set about destroying every mosquito, either in the adult or in the larval stage. If this could be done with sufficient pertinacity, there can be no reasonable doubt that, in the end, the island would become entirely free of them—supposing, of course, that the insects cannot enter the island from without. Another method, equally promising, would consist in attacking not the insects individually but their breeding places; would consist in removing every drop of stagnant water in which

they breed, so that, ultimately, the insects would die out of themselves.

Now in our efforts to rid a locality which is not an island, we need follow only these same principles; but we must remember that, since in most non-insular places the insects can enter from without, efforts to destroy them individually will never be permanently successful. On the other hand, if we keep the area of operations entirely free of breeding places, we shall and must reduce greatly the number of insects, because, even if a few do manage to effect an entry from without, these will no longer be able to multiply within the area as they used to do. It is quite obvious, if we think of the matter for a moment, that one or two breeding places will give rise to fewer mosquitoes than 100 or 1,000 breeding places would do. If, for example, a given town contained 1,000 breeding places producing 100,000 mosquitoes daily, we are forced to conclude that the daily production of mosquitoes would be visibly reduced if all these breeding places were to be obliterated. Any mosquitoes effecting an entry from without would be so few in number, in comparison with the previous swarms of insects in the town, that they would scarcely be observed at all. If we consider the subject then in the light of these facts, we shall be able to decide upon the measure most likely to be profitable; and this is evidently that of removing all the breeding places. But concurrently it will do no harm to attack the insects individually whenever and wherever we meet them.

It has been a matter of serious difficulty to get people to understand these ideas, simple as they are. Even when the advisability of removing the breeding places has been

admitted, doubts as to the practicability of the measure have been entertained. Now the reader will remember that every new project is thought by many before it is tried to be impossible. After they have been tried, new projects often turn out to be not only possible but extremely easy. So it is with the present project. All we have to do is to keep a sufficient staff of men constantly employed upon the job.

Before showing how this can be done, we must describe the breeding places in greater detail.

4. The Breeding Places of *Culex*.—In the gardens and backyards of most houses, especially the houses of natives in the tropics, there are generally numerous tubs, pots, gourds, old buckets, broken flower-pots, empty oil tins and meat tins, broken bottles, and such like. During rainy weather, most of these contain a little rain-water; and wherever this water exceeds a few ounces in quantity, and has been standing long enough, there we shall find the larvæ of *Culex*. Tubs and cisterns employed for collecting rain-water from the roof, or for storing water for gardens, or even for keeping water for drinking, are favourite breeding places if they are left undisturbed long enough. Pots of water left by servants in the neighbourhood of cook-rooms and in back verandahs, and then forgotten, are very suitable. We can even find larvæ in the tins of water placed under the feet of tables and meat safes for the purpose of excluding ants; or in gutters which carry rain from the roof, and which have sagged, so as to contain a little stagnant water after the rain has passed; or in uncorked empty bottles and sardine tins thrown on a dust-heap; or in tin-lined packing cases; or in the hollows of

bamboos, drain-pipes, or even cannon—in fact, wherever a little rain-water can collect.

After the rains, *Culex* larvæ generally exist in collections of water made for gardening or household purposes; cisterns; gutters running from stables, cookrooms, and bathrooms; and old pits and wells. They may occur also in ditches, even in ditches which contain slowly running water.

For practical purposes it is always most important to remember that when a large number of *Culex* exist in a given house, they are, in the large majority of cases, being bred just outside the windows. Thus we often find more *Culex* mosquitoes in one room than in another; and in such cases their larvæ can generally be discovered in a water-butt or flower-pot under the window of the infested room. A few insects may come from the backyards of our next-door neighbours, and still fewer from a little further away; but as a rule the *Culex* mosquito is a home-bred article. It is generally easy to prove this by destroying our own larvæ; after which a marked diminution of the winged insects in the house is almost certain to occur, even within twenty-four hours or so. And we must remember that it is these insects which carry yellow fever, elephantiasis, and perhaps other diseases, besides causing intense annoyance by night and day.

To those who really know about mosquitoes, it is always somewhat amusing to hear less well-instructed people complaining of the number of these pests which surround them, and which they often imagine are blown across seas and rivers by tornadoes, or are bred in countless myriads in neighbouring forests and marshes—the truth generally being that they are bred in their own backyards!

5. Breeding Places of *Anopheles*.—The habits of *Anopheles*, the malaria-bearing variety of mosquito, are somewhat different. These insects breed mostly, not in vessels of water, but in puddles on the ground. But they do not breed in all puddles, but only in those which suit them; and with a very little trouble it is possible to detect at sight the kind of water in which the larvæ will be found.

They are not often found in large bodies of water, such as lakes, where the surface is constantly ruffled by the wind, and where there are many fish to eat them; nor in large rivers; nor in rushing torrents; nor in well-contained ponds; nor in small but deep pools; nor indeed do they thrive much in the deeper parts of marshes and mangrove-swamps. Nor, on the other hand, do they care for very small collections of water, such as the temporary puddles which form on the ground during a shower of rain; because in such puddles the larvæ perish almost at once as soon as the water dries up.

In my experience in India and Africa, *Anopheles* larvæ are found *chiefly* in small shallow puddles on the ground which are not so large as to contain minnows and water-beetles, nor so small as to dry up too quickly. Such puddles are frequently found in depressions in the ground, in badly made drains and gutters, in places where water constantly oozes from the soil during the rains, or where the drainage is checked by out-cropping rock or by embankments and walls, or where water constantly escapes from pumps, stables, bathrooms, and irrigation channels. Small pools containing green mould or water-weed are much affected by the larvæ; and so are pools contained on the surface of weather-worn rock. But on the other hand,

however favourable for the larvæ a pool may otherwise be, it becomes quite unsuitable for them if it be at all exposed to scouring during heavy rain; because, in this case, whenever a heavy shower falls, the larvæ are sure to be swept into rain-torrents and lost. It is indeed for this reason that *Anopheles* pools, and consequently malaria, are seldom found on hilly ground, and that both abound on level soil and in flat valleys between hills.

At the same time it must be understood that these rules are not without exceptions. Thus larvæ may sometimes be found amongst the reeds and partially submerged grass at the margins of lakes and rivers; or in the little quiet bays and creeks of streams; or in the small pools lying at the edge of morasses; or in ponds full of weeds, or in submerged rice-fields, even if these contain a certain number of fish. They may also occur in very small puddles during constant rainfall; and, lastly, may exist in very large numbers in the hollows of rocks left full of water by drying watercourses at the end of the rains.

The natural situations in which *Anopheles* larvæ occur differ to some extent according to the local conditions of drainage and rainfall, but seem everywhere to be determined by much the same general laws.

The larvæ are sometimes found in artificial collections of water, such as disused wells, burrow-pits, cess-pits, garden cisterns, drain-outfalls, and so on. They may even occur in vessels of water, such as water-butts; and are frequently found in the bilge-water of boats lying idle on shore.

Occasionally, especially in the presence of thick jungle, undergrowth, or long grass, it is very difficult to find the breeding places of *Anopheles* at all. Sometimes numbers

of the insects collect round houses or encampments in the middle of the bush, evidently attracted by human beings, though it is not possible to discover their larvæ anywhere. In such cases it is probable that the breeding pools have been overlooked owing to the copious vegetation, or that the insects are old ones which have lived in the bush since the last rainy season. Fortunately these conditions do not obtain much in large towns, where the fight against mosquitoes must chiefly be waged.

But, though *Anopheles* can scarcely be said to be "home-bred mosquitoes" to the same extent as *Culex* are, they are generally most numerous in houses nearest to the breeding pools. They naturally select the nearest houses for obtaining their human food. Freetown, Sierra Leone, presents several examples of this. The unhealthiest and most *Anopheles*-haunted parts of the town are just those parts where the pools and puddles are most numerous. It was shown by CHRISTOPHERS and STEPHENS that in the dry season there the insects were most prevalent in houses adjoining a drying water-course full of puddles. In Tower Hill Barracks, situated on a small open eminence in the middle of the town, *Anopheles* are very rare, though this eminence is, or rather was, surrounded by numerous pools at a distance of a few hundred yards—the reason being that the *Anopheles* bred in the pools preferred to obtain their food in the houses of natives at the foot of the eminence, to wandering up the hill in search of it.

In short, *Anopheles*, like other mosquitoes, and indeed most animals, are essentially local in their habits. They are most numerous where they can breed and feed most easily. They are not spread uniformly over the country like the air we breathe. The idea that swarms of them

can be blown into towns by winds from distant marshes is erroneous. If we remove the breeding pools at any one spot we shall certainly largely reduce the *Anopheles* at that spot, even though a few insects may occasionally wander in from without. In other words, in most towns where they are numerous we may be sure that the vast majority of them are being bred in the town itself—in the gutters, the ditches, the street puddles, the gardens and ponds which lie amongst the houses.

In searching for Anopheles larvæ it is most necessary to use a white bowl, or a white mug fastened to the end of a stick; because the larvæ are often almost invisible in clear water with a dark-coloured bottom.

6. How to Find the Adults.—During the day the winged insects can be frequently observed sitting on the walls, or under the roof, or in dark corners, and especially in dark clothing, and inside hats hanging on pegs, and in bathrooms, stables, and rooms occupied by natives. But the reader must be warned that the number of insects caught in houses during the day gives no accurate measure of the number, especially of *Anopheles*, present during the night. It is chiefly females gorged with a fresh meal of blood which remain in the houses, the others generally flying out in the early morning. Thus houses in which scarcely a mosquito is visible during the day may be visited by large numbers at night. This may often be proved by persuading a native servant to sleep within a mosquito net which has several small holes or rents in it. Such a net acts as a *mosquito-trap*. During the night the insects explore every part of the net in the hope of reaching the inmate; and many find their way in, but when

morning arrives cannot find their way out, and can then be killed and counted.*

When people say that mosquitoes swarm in a place they generally refer to the insects in the *house* in which they happen to be staying (which is quite a different thing to the *place*, *i.e.*, the town or locality). They are also generally speaking of *Culex*, which, I think, hum more than *Anopheles*. Moreover, the "swarm" generally really means only some dozen, or even fewer insects, which are attracted by the teller of the tale. One or two pertinacious mosquitoes often give a casual observer the impression of a swarm being present.

All these facts make it a difficult matter to arrive at any really correct estimate of the actual number of mosquitoes existing anywhere.

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* This mosquito-trap was suggested to me by Drs. ANNETT and DUTTON, and was used with astonishing results by Dr. STRACHAN and myself at Ibadan, Lagos, in a house where no mosquitoes could be seen in the daytime.

THINGS TO BE DONE.

7. Appointment of Superintendent.—Having given a few preliminary observations, we now proceed to consider how the fight against mosquitoes can best be commenced and carried on. The first thing to do is to appoint the superintendent or commandant-general of the mosquito brigade. Fortunately, this can always be accomplished without any gazette extraordinary or orders in council. Anyone can appoint himself, with as handsome a salary as he can afford out of his own pocket.

It is best, perhaps, that the superintendent should be the health officer of the town in which operations are to be carried on, and next best that he should be a medical man; but an energetic layman is quite capable of doing the work.

The qualities chiefly necessary are energy, persistence, and an entire indifference to public or private opinion. The need of the first two is obvious; that of the last requires some explanation. The self-appointed superintendent will be at once astonished, and perhaps alarmed, at finding that his philanthropical and wholly harmless efforts are met at the outset by a storm of letters to the local press, demonstrating the absurdity and even immorality of his intentions; proving that mosquitoes cannot be destroyed, that they spring from grass and trees; that they can be destroyed, but that it is wicked to make the attempt because they were created to punish man; that they do not carry malaria, because malaria is a gas which rushes out of holes in the ground, and rises as a blue mist over the country; that they do not carry yellow fever, which is due

to the effect of the tropical sun on rotting vegetation; that they do carry malaria and yellow fever, but in such small quantities that they act beneficially as unpaid vaccinators of these diseases; and so on.* It is possible to ignore all such epistles, because, where they do not contradict each other, someone else is sure to contradict them; but an occasional letter in reply does good, and, to speak practically but rather cynically, serves to stimulate the necessary public interest in the work by keeping the letter-writers at such a pitch of exasperation that they give the campaign a constant stream of gratuitous advertisement in the newspapers. We are permitted to be cynical in a good cause.

Fortunately, operations against mosquitoes can be conducted on a large scale without much reference to private opinions—fortunately, because the inertia of the masses regarding new pathological discoveries is so great that were we to depend upon converting them, nothing would be done for half a century. For some inscrutable reason, the man in the street, though he would scarcely think of contradicting a lawyer or an engineer on matters of law or engineering, finds himself quite equal to exposing the absurdities of the whole Medical Faculty on a medical matter.

These operations require no sacrifices or co-operation on the part of the general public. Most householders are glad enough to have their mosquito larvæ destroyed, and their backyards cleaned up for nothing. The reader, therefore, if he sees fit to start the work we are considering, may quietly proceed in it undisturbed by criticism, and may calculate upon receiving not only as much public support

* I have seen every one of these statements, and many others equally absurd, made at least half a dozen times in the British press.

as his work will require during its progress, but the thanks of his fellows at its termination. Indeed, the majority of the public will not be slow to recognise the value of his efforts, even if they do not understand the scientific reasons which have induced him to make them.

8. The First Step.—The superintendent, whether self-constituted or, as may sometimes be the case, appointed by the local authorities, should begin by searching out the principal breeding places of mosquitoes in the area in which he desires to work. He may calculate on finding *Culex* larvæ everywhere; but the *Anopheles* larvæ will require some trouble to hunt up; because it is necessary to find not only one or two breeding pools but all of them, or at least as many as possible.

He should also study the culicicidal effect of the several kinds of petroleum oils to be had in the local market (*see* paragraph 14), and should carefully consider the means he intends to adopt for draining away or filling up the local *Anopheles* pools. A few hours' work daily for a few weeks will suffice for this part of the campaign. The next thing to do is to originate and organise the mosquito brigade; for which the first thing required is—sufficient money.

9. How to Raise Funds.—Generally, when a health officer or other medical man wishes to float some sanitary scheme for the good of the community, he begins by preparing a long report, flanked with numerous statistics, estimates, and scientific quotations. This he submits, through the proper official channel, to the local municipality or government. The answer which he invariably receives, after some months' or years' delay, is that the funds in the local or imperial treasury are not sufficient to

meet the expenditure required for the scheme proposed by him; and that usually brings the praiseworthy project to an abrupt conclusion.

Unless the superintendent happens to be an agent of government employed for the work, which is at present not very likely to be the case, this is pretty sure to happen in connection with any project for ridding a town of mosquitoes. The government or municipality will reply that it is not their business to kill mosquitoes; that they already possess an expensive and efficient health department; and that if householders wish to get rid of mosquitoes, they had better destroy their own larvæ. And as householders certainly will not take the trouble to do anything of the kind, the matter will rest there, and the mosquitoes will continue to thrive as before.

From my own experience, I advise the self-appointed superintendent to adopt a much more practical and effective course. He should go at once to the principal banking establishment in the town; inform the managers that he intends to open a fund for a campaign against mosquitoes; ask for good terms,* and put down an initial deposit out of his own salary (obtained as mentioned in paragraph 7). Next he should go round to his personal friends, to the principal business houses in the town, and to anyone else he can think of; inform them that he has already opened the fund, and ask for as much money, up to four figures, as they are willing to give. I should be much surprised if he does not find himself in possession of a handsome little account within a few days.†

* I obtain 3 per cent. interest on all deposits, and transfers to the tropics free of cost.

† For our West African Fund, I have started with between two and three thousand pounds, and promises of as much more as we shall require.

The next thing required will be a sufficiency of oil for killing larvæ; of brooms, pickaxes, and shovels for brushing out or draining away *Anopheles'* pools; and of cement for filling up pools in rocks. Now in this campaign the principle to go upon is never to buy anything; it is much more economical to ask well-to-do people for these trifles. I should again be much surprised if all the oil, brooms, spades, and cement required were not forthcoming in a day or two (such at least has been my experience).

Strict accounts should be kept, and should be submitted to the subscribers, with a brief report of progress, every quarter.

The superintendent may here ask whether he is not justified in charging the fund for his own services. I think he is, provided the amount does not exceed a shilling a week, and is debited to "postage."

10. Small Beginnings.—We now commence at once to start the brigade. This will consist of one or more head men and as many workmen as the state of the treasury will allow. For their salaries the fund may be freely drawn upon.

The superintendent need not think that he must start with an army corps. Indeed, a brigade of one man besides the superintendent is a good working force to begin with, if the treasury is very low. But my advice at this point is, not to be too parsimonious, but to spend freely on labour. Above all, take no thought for the morrow, but go straight ahead.

In the tropics labour is generally very cheap—from ten to twenty shillings a month for each man, and something additional for each head man. Thus for a trifle of ten

pounds, between ten and twenty workmen may be set to work for one month; and I can assure the reader that ten or twenty men working for a whole month will do a great deal of good against mosquitoes.

At this juncture modesty is a great fault. The brigade, however small it may be, should be immediately set to work in the most obtrusive fashion. It will grow as it proceeds. A public dinner and an after-dinner speech will work wonders. The superintendent is justified in stooping to any underhand tricks to obtain money. But the best way is to show work being actually done. This will make the treasury overflow.

A conscience is not necessary for this work. As soon as he has enough money, the superintendent should demand more. He should no longer beg for it as he used to do, but insist upon it. At the same time he must increase the force, and extend his operations in every direction.

Having abandoned all scruples, the superintendent must now openly avow piratical designs, especially upon government. He will need carts, more men, implements, permission to fill up pits and ponds, and to drain puddles in the streets. All these are to be obtained from the local municipality or government. Municipal carts are excellent for carrying away broken bottles and flower-pots and empty tins, and for bringing earth and gravel to the workmen. The Public Works Department possesses all kinds of useful implements, besides other nice things, such as cement and rubble, and one or more skilled engineers whose advice will be very useful. In the public gaol there are sure to be a number of prisoners engaged in doing shot-drill; these men would be much better employed in draining the streets. Without money or men the superin-

tendent was a cipher; now that he possesses both he has become formidable. He should call at once on the highest official present and extort what he wants without paying for it. The official will probably be a willing victim.

I describe these machiavelian methods in detail to show how easy it is for anyone, provided only that he has the necessary energy and enthusiasm, to inaugurate this useful work in the town where he lives without waiting for or depending upon official action. And, generally speaking, there is a great deal to be said in favour of the campaign being commenced by private enterprise in this manner. But where the government or municipality do themselves decide upon carrying on the fight against mosquitoes—and the interests of public health demand that this should be done more often than it has yet been done—these initial manœuvres will not be necessary, and the superintendent can at once proceed to organise and instruct his little army.

Several junior officers of colonial medical services have written to me expressing regret that, though they are anxious to begin operations against mosquitoes, they can obtain no funds from government for the purpose. My advice to such is to raise the money among business people and others in the colony, and to begin at once without reference to government. Government is sure to come forward later as soon as it knows from experience exactly what will be required of it.

11. Organisation of the Brigade.—Every man should be given a badge. A diamond-shaped patch of red flannel sewn on the arm or breast is a good one.

Working hours and pay day should be fixed.

A list of all the workers should be kept.

Pay should be generous, as the work is of a special nature, and it is advisable to retain the men after they have been taught the work.

Natives, both of Africa and India, take kindly to the work and are often very smart at it.

The men should be invariably paid either by the superintendent himself or by a completely trustworthy agent.

The brigade should be at once divided into two gangs, a *Culex* gang and an *Anopheles* gang. Each gang should be under a special head man, who should be selected for his special intelligence and honesty, and should be given very good pay.

The superintendent should begin work by instructing each gang, especially the head men, regarding their duties. They should be shown how to find and distinguish the larvæ both of *Culex* and *Anopheles*, and also how to find, distinguish, and catch the adults. But it is not necessary to spend much time over this, nor to go deeply into the matter. The men will easily learn their work as they proceed.

Where funds do not permit of two gangs it is best to begin with the *Culex* gang, unless malaria is very prevalent, because *Culex* mosquitoes are, as a rule, the more troublesome and perhaps the more easily suppressed.

12. Organisation and Duties of the *Culex* Gang.—The duties of this gang will carry them much into private premises. It is, therefore, very necessary that all the men should possess characters for honesty; and the head man must be a particularly respectable person. In India, where natives often object to low-caste people entering their

yards, he must be a man of good caste. Each man should be given a card specifying his name and duty, to carry with him as a credential.

In English towns, rubbish of all kinds is kept in proper dust-bins, and is removed regularly by proper agents; but in the tropics the utmost carelessness prevails in this respect. Even in the houses of Europeans, old buckets, bottles, and meat-tins are left by the native servants strewn about everywhere. Rain-water remains in these for months, and contains thousands of mosquito-larvæ, giving rise to numbers of mosquitoes, which immediately enter the windows of the houses and persecute the occupants—who, of course, attribute their presence to any marsh which may happen to exist within ten miles of the place.

The first duty of the gang will be to collect all the broken bottles, tins, broken flower-pots, old gourds, and such like, which they can find either in private premises or in the streets. The procedure as regards the private premises is as follows:—The head man informs the master or one of his servants of his errand, and offers to remove all his broken bottles and old tins free of cost. In the vast majority of cases, the offer is accepted with alacrity. The rubbish is then collected by the gang, and placed in a heap near the door; and next, in order to prevent accusations of theft, the head man must ask one of the inmates whether the heap contains any article which is required. This is an important form, because natives often attach value to all kinds of trifles. On permission being given, the whole heap is piled into a cart and removed, together with similar collections from other houses, to an assigned dumping-ground.

One or more carts, drawn by horses, mules, or oxen, can generally be borrowed from the municipality.

The dumping-grounds should be situated as near as possible, in order to save time in transit. The rubbish can be most effectually used in filling up ponds and burrow-pits; otherwise it must be discharged at the municipal dumping-ground.

Dr. LOGAN TAYLOR and myself found, as the result of our work in Sierra Leone, that a gang of six men can keep one large mule-cart fully employed, and that on the average it can clear fifty houses and remove ten cartloads of broken vessels daily—one cartload for every five houses.

The head man must keep an account of all the houses cleared by his gang, and also of the number of cartloads removed. He must be extremely polite to all the inmates of the houses—especially to the older ladies. If, as sometimes, but rarely, happens, he comes to a house where the owner forbids his entry, he should simply leave that house alone (being, however, careful to record the address for future reference), and go on to the next one.

But the head man has also other duties to perform. In every house he will find several tubs or pots of water stored for use by the occupants, and in many of these he will find crowds of *Culex* larvæ. He should call attention to the larvæ, and endeavour to explain that they are the young of mosquitoes. If he is not believed (which, so advanced is education among the people, will generally be the case—even among certain classes of Europeans) he should place a few larvæ in a bottle half full of water, bunged with paper, and tell the sceptics to keep them under observation for a few days. He should then ask leave to pour out the larvæ remaining in the vessel in which they were originally found, upon the ground, where they will speedily perish. If, however, the water in the vessel is required by the

inmates of the house, the larvæ can be destroyed in their presence by pouring a few drops of kerosene or eucalyptus oil on the surface, as described in paragraph 14. The same can be done with larvæ found in pools on the ground, or in the pits so frequently used by natives for washing clothes in. After the oil has killed the larvæ, it evaporates, leaving the water as fresh as before.

At the rate of fifty houses a day, a gang of five or six men will, in a few months, collect most of the broken pots and tins in a town of considerable size. If funds allow, and if greater rapidity be desired, several similar gangs, each under its own head man, must be employed.

When the gang has cleared all the houses within the area of operations, it must begin at the first house and go over the whole ground again. But at the second visit its progress will be more rapid, because there will not now be so many vessels to collect. Moreover, many of the inhabitants will have now learnt to destroy their own larvæ.

If the brigade is supported by voluntary contributions, it is only just to appoint special men to destroy larvæ in the houses of the principal contributors and their neighbours. This can be done while the combined gang is collecting vessels throughout the town. Later on it will probably be possible to extend this system, and to appoint a special man to keep down the mosquitoes in each block of buildings. One man ought to be able to deal in this manner with about four hundred houses, visiting sixty or more daily. But this can be done only after most of the broken bottles and tins have been collected.

People should be encouraged to report the presence of numerous mosquitoes in their houses. When this is done, trained men can be sent to find the cause of the invasion.

It will generally be a pot of stagnant water in the back-yard; but sometimes, as mentioned in paragraph 4, the larvæ will be found actually within the house.

The good effect of these measures will be speedily noted and appreciated by the public. I have frequently observed that as soon as all the stagnant water is removed from the precincts of a house the adult insects leave it within a day or two—probably in order to find water elsewhere to lay their eggs in; and once gone they do not return, unless stagnant water is allowed to accumulate again.

So far as I can estimate for a town in the tropics, consisting of Europeans and natives mixed, a dozen intelligent, trained, and active men, permanently employed, ought to keep five thousand houses free of *Culex*. The salaries of these men at about £1 a month each, and the cost of a few sundries, such as kerosene oil, ought not to exceed £150 a year—a very small sum indeed to pay for such a boon as the banishment of *Culex* from so large an area.

I have said that a householder who refuses to admit members of the brigade ought to be left alone. He will come round in time; but this raises the question of the possibility of employing legal measures against people who annoy their neighbours by breeding mosquitoes. Municipal regulations on the point would be quite justifiable; and in Havana the straight-thinking Americans quickly fine a person who breeds mosquitoes. But from a very considerable experience of British methods, I would advise a British superintendent of a mosquito brigade to trust rather to persuasion and to his own energies than to any assistance from the law.

13. Organisation and Duties of the *Anopheles* Gang.—The duties of this gang will consist principally in removing all small collections of water on the surface of the ground. Hence the men should be, if possible, *road-makers*, and well accustomed to the use of the pick and shovel. The head man should be a trained overseer of navvies; it will be useful if he is also acquainted with the methods of working cement and concrete.

In almost all towns, especially in the suburbs and surroundings, there are numerous burrow-pits from which earth was formerly taken for building and road-making; also ditches, old cisterns, gravel-pits, disused wells, water-courses, broken gutters, ponds, and even sometimes small marshes formed by the margins of lakes or by ooze from the soil. In rainy weather these fill up with water, and then often take a long time to dry up again. In temperate climates such places are harmless; but in warm ones they become a source of danger to the surrounding houses by breeding *Anopheles*, the malaria-bearing mosquito.

Besides these, in ill-kept tropical towns, numerous small stagnant puddles form in the public streets. In such towns it is the exception to find well-macadamised streets with pavements and stone gutters; and the streets are generally nothing but broad pathways, dressed with rubble in the middle for the wheeled traffic, but drained only by rude ditches at the margins. Tropical towns cannot as a rule afford highly trained engineers for road-making, and the result is that these roadside ditches are often very badly constructed. One of the principal errors, common both in India and Africa, is that the ditches are often much too large for the amount of the water they have to carry off. Where a small gutter would have sufficed, we often find a

huge trench of a square foot or yard in section. The reason for this frequent anomaly probably is that the larger the ditch is the greater its cost; and the greater its cost to the municipality, the larger the amount of money which sticks to certain fingers. Whatever the reason may be, the results are disastrous. In the first place, the cost of "draining" the streets is ruinous to the municipality; in the second place, the ditches frequently do not drain the streets at all, but merely constitute strings of stagnant puddles running in front of the houses and breeding thousands of *Anopheles*. Thus in Freetown, Sierra Leone, there are numerous old trenches cut in the solid rock at great cost, and always full of nearly stagnant water; and I have often seen the same thing elsewhere. Many gutters, moreover, are made without any due deference to fall, and are almost level from end to end. Other principal causes producing stagnant pools are neglect to repair the surface of the roads; carelessness and want of supervision regarding the disposal of storm-water from private premises; and, very particularly, out-crops of weather-worn rock, which is not only full of hollows itself, but "contains" the surface-water by natural ridges of stone.

The way in which most municipalities would deal with such defects is the following:—The local engineer would be asked to prepare a scheme of surface drainage for the town. After a year's surveying (with a thousand pounds spent on maps and measurements) the scheme would be ready. The cost would probably work out at a thousand pounds for every few acres. The scheme would be submitted for approval to the superior government, which, after another year or two spent in considering it carefully, would reply that there are no funds available.

I do not recommend this procedure. The fact is that the large majority of the puddles can each be obliterated, temporarily at least, by a stroke or two of the pick and shovel, and a few basket loads of gravel. It is necessary only to set the gang at work straight away, and they will probably clear out most of the stagnant water in a few months. A formal drainage scheme had better be abandoned until simpler methods have at least been tried and have failed.

But in order to obtain the best results the superintendent must proceed with method. He should be guided by the following important principle: Attack first those collections of water the obliteration of which will remove the largest number of mosquitoes for the least amount of money. Thus, it is quite useless to drain stagnant water simply because it is stagnant water. The superintendent should first assure himself that it does actually contain larvæ, and, better, that it constantly contains them. As already mentioned, some pools are too large, others are too small, and others are subject to scouring; and, though these conditions often change at certain seasons, when, for instance, large pools dry up, yet some pools appear to be habitually unsuited to the larvæ.* It is useless to spend much money over these. Again, it is not advisable to attack without discrimination even the pools which do contain larvæ. Some contain many more larvæ than others do; and, in my experience, while larvæ do occur in some considerable bodies of water, such as marshes or ponds, they

* On revisiting Freetown after two years' absence, I was struck by finding the larvæ in exactly the same pools, however small; while other pools previously negative, remained negative. The most insignificant puddles seemed to be much more permanent than would be thought possible, and year after year fill up with rain and breed mosquitoes.

are generally much more numerous in small pools. Now, it is evidently bad economy to spend large sums over draining large bodies of water, when small puddles, easily dealt with, really cause more mischief. The superintendent must *suppose* nothing—he must never *suppose*, because a marsh exists in the neighbourhood, that it is the only or the principal cause of the malaria. He must study the point by careful search for *Anopheles'* larvæ; and may often find that a small unobserved pool in the street is more dangerous than a marsh a mile away.

The number and nature of the breeding pools depend so much on the configuration of the ground, the character of the soil, and the amount of the rainfall, that it is impossible to give very minute directions regarding the method of dealing with them. The superintendent must be guided by his own judgment, remembering only the maxim, which applies to most kinds of work: The simplest measures first. Some general advice may, however, be useful.

Small Pools.—Wayside ditches, which have been simply dug out in soft soil, and have become full of pools in consequence of silting, require alternate filling and cutting so as to be converted into a channel of uniform calibre and fall. Where the obstructions are caused by rock, this must be cut through by means of the pickaxe or jumper. A channel six inches square in section is enough to drain most roads where water does not come down from above. Turf or stamped rubble are good for binding the edges of such a channel cut in soft earth. Vegetation in the course of the channels should be cleared, but not on the banks. Pools formed in depressions or flat surfaces of soft soil should be filled with rubble, gravel, or earth. When they are contained by outcrops of rock, the latter must be cut through

and the pools filled with gravel or rubble. It is seldom necessary in such cases to make formal stone, brick, or cement surface-drains, or to lay in subsoil pipes. We must remember that puddles can be spoilt for larvæ, even if they are not entirely drained away; either by running a current of water through them, or by breaking up their surface with stones and rubble. Pools formed in the soft earth at the bottom of water courses require filling in with large stones and gravel. Pools in the hollows of rocks, as those found in the bed of drying streams, require to be filled up by concrete (one part of Portland cement to two of sand) mixed with stones; or they can be often released by cutting the rims of rock. Water lying on flat fields or other surfaces can generally be released by small crow's-foot channels—the smaller the better. Boggy ground on the margin of ponds, tanks, and streams, can be dealt with similarly. Made surface drains should be kept free of silt.

Deeper Pools, Pits, and Ponds.—These should be filled up where possible by earth, or by rubbish collected from the houses. Where they cannot be filled up they can often be spoilt for larvæ, by clearing away the vegetation on their banks in which the larvæ love to hide. Larvæ do not like open water of any depth, especially when it is free from vegetation. It is astonishing how soon even large pits and ponds can be filled up with rubbish collected from houses by the *Culex* gang (paragraph 12).

Disused Wells, Pits, and Tanks.—These should be filled up if possible; or cleared of vegetation and oiled regularly. Owners of premises often give great trouble about such places; in which case the municipal authorities ought to be approached on the matter. Often, however, no larvæ exist in them.

Used Wells, Washing Pits, and Drinking Pools.—When these contain larvæ, which is rare, recourse must be had to clearing vegetation and to periodical oiling. Wells can always be protected by a mosquito-proof cover with a small wire gauze grating for the bucket—as done at Bathurst, Gambia, and other places.

Streams.—Sedges and grass on the banks of sluggish streams sometimes shelter larvæ, and should be lifted. Torrents, which in the rains cannot harbour larvæ, may become prolific sources of mosquitoes when they begin to dry up. Cementing the pools in the rocks, "training" the banks, and a generous use of the broom at the end of the rainy season are the things required.

Marshes.—These must be gradually filled or drained; but this work ought to be undertaken by government. Gaol prisoners can be most usefully employed on the task, as at Lagos. It is probable that in most cases as much good will be done by clearing the rank vegetation, and by deepening the marsh and converting it into a lake, as by filling it up or draining it. A small *Anopheles* gang can generally do effective work by draining and dressing the boggy ground at the proximate margin of the swamp, or by oiling the marsh in the dry season, as is often done in America.

All this looks very formidable on paper. It is not so in reality. A very few men working day after day will do wonders in the course of a few months. The great thing is to make a beginning: not to form counsels of perfection, not to measure means with ends, but simply to set to work with whatever force there is available, however small it may be. A single private citizen can eradicate malaria from a whole town. In an enter-

prise of this nature, the means grow as the work proceeds.

As already mentioned, the number and nature of the breeding pools depend greatly on local conditions. Freetown, Sierra Leone, contains perhaps an excessive number of pools. It was indeed partly for this reason that it was selected for the first formal campaign against mosquitoes, because success in its case would demonstrate the possibility of success in more favoured places. In Freetown there is a great rainfall (160 inches annually), and the ground, though hilly, is such that water collects in many spots. Even here, however, the *Anopheles* pools are not without limit, and a gang of twenty to forty men has been able to produce marked effects in so short a period as two months (*vide* Appendix). In my experience, most other towns will be easier to deal with than Freetown is, because they possess either a less humid climate or a more absorbent soil. In many localities, indeed, the breeding places will be found to be very few.

Much effect will be often produced in the dry season, when the pools are necessarily small in number and the larvæ are concentrated. In the rains they spread themselves more widely of course.

Perhaps the principal difficulty in dealing with *Anopheles* lies in the fact that they often breed in waters which, being required for drinking, washing, and irrigation purposes, cannot be drained away. Here the superintendent must be guided by his own common sense. It is generally, perhaps always, possible greatly to limit the number of such waters by closing those which are not really needed. The rest must be dealt with by cleansing from weeds, deepening, banking in, covering, or by persistent oiling. In all tropi-

cal towns, natives are very fond of digging holes and banking up surface drains. The local government ought to set its face against such doings. With a pipe water-supply, and specially constructed cisterns for washing clothes, most wells and washing-pits may be filled up.

It will sometimes happen that the breeding places cannot easily be found owing to a quantity of rank vegetation. It is very wrong to allow such in the middle of towns, and the presence of ill-kempt areas full of weeds is a proof of incompetent municipal management. Efforts should be made to clear up such places. *See* YOUNG'S Paper in the Appendix.

A large proportion of the sickness prevalent in tropical towns is directly due to mismanagement on the part of the local authorities. These nearly always show a tendency to pay the least possible attention to the cleanliness and tidiness of their towns. Much of the money available for sanitation is often spent, not on getting the work done, but in paying far more than the market value for supervising officers who—draw their salaries and write reports. It is high time that a radical change be made in these matters. Leading citizens who cannot get improvements made by quieter means will generally obtain attention if they write to the principal home papers on the subject. It is monstrous that large towns should be allowed to remain in the disgusting condition in which, as a matter of fact, they often are.

14. Destruction of Larvæ.—As argued in paragraph 3 it is better to obliterate the breeding places of mosquitoes than to spend much time over merely destroying the larvæ. We may continue to destroy the larvæ with oil for months, leaving the pools themselves alone, and yet

find that after every operation fresh eggs are laid by the adult insects living in the houses, and that fresh larvæ develop. It is indeed probable, if not certain, that if the work of destruction be carried out over a considerable area, long, thoroughly, and persistently, the mosquitoes will end by being vastly reduced in that area (unfortunately the experiment has never been thoroughly made); but the same result can be obtained more permanently, and in the end probably more economically, by obliterating the breeding places themselves.

Nevertheless, while the other work is in progress, it will do no harm to destroy larvæ wherever they are met with—which can be done either by the workmen in the course of their work, or by special men employed for the purpose. Indeed in some places, such as those just referred to, namely, collections of water in use for drinking, washing, and irrigation purposes, it is often impossible to drain at all, and the superintendent must fall back upon destruction of the larvæ.

Numerous means of destruction have been suggested —such as the introduction of fish, and of many chemical poisons or substances inimical to the larvæ. Fish, tadpoles, some kinds of beetles, and other animals do eat larvæ; but, unfortunately, they cannot always be introduced; and even if they are introduced, it is evident that their efforts will not always be successful, since we often find living larvæ in the same pools with them. It is much the same with chemical poisons. Waters which can be poisoned are those which are not required, and which had, therefore, better be drained away at once. Moreover, few poisons are effective against larvæ unless concentrated; and then most of them become dangerous, inasmuch as children and

cattle may suffer from our well-meant zeal. I have long wished to find an ideal poison for mosquito larvæ. It should be some solid substance or powder which is cheap, which dissolves very slowly, and which, when in weak solution, destroys larvæ without being capable of injuring higher animals. What a boon it would be if we could keep the surface of a whole town free from larvæ simply by scattering a cheap powder over it, once in six months or so. It is very possible that such a substance exists, but unfortunately we have not yet discovered it. Many chemicals kill larvæ, such as those on which CELLI and CASAGRANDI have experimented (*see* Bibliography); but these have hitherto proved disappointing in practical work.

On the whole, oil remains the best larvacide up to the present. Any oil which forms a thin film on the surface of water destroys larvæ by choking their breathing tubes. Rock-oils, both crude petroleum and refined lamp oil (paraffin or kerosene oil), and creosote are most commonly used. A waste product called blast furnace oil is very effective. STRACHAN and BATTYE* recommend eucalyptus oil, and, since the action seems to be mostly mechanical, many oils would, I fancy, serve equally well.

The oil must produce a film which spreads over the whole surface of the water, and which lasts for an hour. Different samples of oil differ so much as regards these points (and also as regards price) that I refrain from specifying the best ones by name; the superintendent should examine for himself the cheapest oils in the local market. The rapidity with which the film spreads depends upon a slightly soluble constituent in the oil. MR. HANKIN, of Agra, informs me that the addition of amyl

* *British Medical Journal*, 1901, vol. II., page 929.

alcohol greatly expedites the formation of the film; and it is very necessary to obtain a film which makes its way between the stalks and leaves of water-weeds. The duration of the film depends upon the amount of oil used and its rapidity of evaporation. Heavy crude petroleum generally makes a slow film, but one which may last for weeks; while the more refined lamp-petroleums, such as kerosene, spread quickly, but evaporate sooner. Crude creosote spreads quickly and lasts long, but does not seem to be very lethal; blast furnace oil spreads and lasts well, and is also very lethal. I speak from experience of the samples tried by me, and cannot answer for other samples. The crude oils are, of course, much cheaper than the refined ones.

Where the water to be treated is waste water, crude oils making a durable film are the best to use; but when we are called to deal with drinking or other water in which it is desired to destroy larvæ without pollution of the water, evaporating oils are indicated. Thus, fine kerosene or eucalyptus oil will kill the larvæ in wells or cisterns of drinking water without imparting a disagreeable flavour.

The mode of application is often of importance. Oil poured in slowly often does not spread as well as when it is sprinkled violently, or "painted" over the water by means of a rag tied to the end of a stick.

Numerous similar details are referred to by writers; but it is scarcely worth while discussing them here, as any man of sense can find out such "wrinkles" for himself. The chief thing to do is to use the oil in a manner to kill the larvæ, and not merely to make a film which looks as if it should kill them. It is not unusual, on returning to a pool some hours after an application of oil has been made, to find the larvæ just as numerous and happy as they were before.

I come last to the best and cheapest way of destroying larvæ—when practicable; and that is by emptying them out upon the dry ground—where they quickly perish (unless it is raining). For vessels of water, empty them out on a gravel patch or on absorbent earth; for small puddles on the ground, brush them out with a broom.

After all, the broom is perhaps the most deadly weapon in the hands of the *Anopheles* gang. After an isolated shower of rain, or when continuous rains are breaking up into single showers; when the sun comes out brightly, and innumerable puddles, which would normally remain for weeks and breed legions of mosquitoes, lie seething on the ground, then comes the triumph of the broom. Every available man is armed with this primeval weapon, and the contents of every puddle, with its delicate inhabitants, are dashed out on the heated soil, or swept into the swollen gutters and watercourses—a whole generation wiped out in a few hours' work.

After the area of the town has been properly drained, the broom will still be required here and there for removing chance collections of water.

In some cases where neither drainage nor oil can be employed, it may be possible to catch the larvæ by means of muslin or wire gauze nets—as for example in wells.

15. **Destruction of Adults.**—As already mentioned, I have often observed the fact that very soon after all collections of water have been removed from the vicinity of the house, the adult insects living in the rooms disappear. I presume that they wander away elsewhere to find water to lay their eggs in or to drink, and then forget to return.

Removing rank vegetation round the house, cutting down trees close to the windows, and taking away flower-pots from the verandahs, seem often to assist towards the same result. I prefer houses to be situated in an open, well-kept "compound," with trees at a distance; and I always dislike (in the tropics) houses surrounded by fertile gardens full of cisterns, irrigation pools, and the like. Towns in the tropics should contain as little bush, rank vegetation, and long grass as possible. On the other hand, I do not think that there is much objection to a moderate number of large trees; and experience shows that, if breeding-waters are carefully excluded, mosquitoes may not exist even in proximity to much vegetation.

In dealing with mosquitoes then, the first thing to be done is to remove the breeding-grounds. Attempts to kill the adults will not, as a rule, be profitable, because the time taken in making such attempts will generally be better spent in attacking the larvæ.

In some cases, however, notably in houses infected with yellow fever or malaria, it becomes necessary to destroy adult mosquitoes, because it may be safely assumed that many of the insects contain the germs of these diseases. The insects can be easily killed by hand as they sit on the walls; or can be caught in butterfly nets, or by placing bottles over them when they are seated. But the method most frequently adopted is that of closing the doors and windows and burning some insecticide substance in the house.

Numerous patent insecticides are in common use for the destruction of green-fly and other pests by fumigation in conservatories, and can usually be obtained from gardeners and chemists. When these are not locally pro-

curable, we may burn sulphur, tobacco, or pyrethrum. The sulphur is put in a strong pot, placed in a basin of water, and lighted. Tobacco mixed with shreds of coarse, damp, brown paper is put in a large tin standing in a bath and lighted. The pyrethrum has to be obtained from chemists, and burnt. After the experiment the mosquitoes found on the window-sills must be examined to see whether they are really dead.

In the majority of the houses of natives these operations are quite impossible, because such houses frequently possess no glass windows, and cannot therefore be effectively closed. In short, where general measures against mosquitoes are contemplated, I advise that no time and money be wasted in killing the winged insects.

Since my researches of 1898 were published, much nonsense has been written by people who have sat down to make books on the subject without any previous practical knowledge of the habits of mosquitoes. This is particularly the case with certain Italian writers who have a custom of imagining facts when they cannot discover them in the works of other persons. Thus it is hopeless to attempt to destroy mosquitoes by attracting them by means of a bright light, because, as a matter of fact, mosquitoes are repelled and not attracted by light.* We see photographs of philosophers going forth to hunt mosquitoes in the Campagna, armed *cap-a-pie* with green veils round their hats and thick gloves on their hands; and we read sage advice given to generals to caparison in the same heroic attire whole armies when on the march in the tropics. The fact is that, in the tropics at least, mosquitoes rarely bite

* See for example CELLI'S *Malaria According to the New Researches* (EYRE'S translation), pages 203, 210, and 212.

out of doors, and then only when their victim is lying or sitting still.* Lastly, we are advised to keep away mosquitoes by hanging bags of camphor or garlic round our necks, or by smoking; all certainly useless. I have seen a swarm of mosquitoes in a cupboard reeking with camphor, and I have never perceived the slightest effect from smoking—at least upon the mosquitoes. The efficacy of several substances as culicifuges has been vaunted. Perhaps kerosene oil and oil of lavender have the greatest amount of evidence in their favour.

16. Last Stages of the Campaign.—If the mosquito brigade was started by voluntary contributions, the superintendent will generally find as the work progresses that, while with the funds at his disposal he has been able to do a vast deal of good and has been able to remove the majority, or, at least, many of the breeding waters, yet that certain waters remain which are beyond his scope to deal with, and also that many of his rough-and-ready methods of drainage are not permanent. If this be the case, he should now bring more and more pressure to bear on the municipality to deal effectively with the matter. And the matter is one which lies pre-eminently within the duty of every municipality to deal with. The thorough drainage of the streets and the obliteration of stagnant pools within municipal limits, constitute one of the functions for the performance of which all municipalities have been given

* In twenty years' experience of the tropics, I remember to have been bitten only three or four times out of doors. Gnats certainly seem to bite more frequently in the open in temperate climates; though many open-air bites are probably due to midges. In India there is a jungle mosquito—a kind of *Stegomyia* probably—which occasionally attacks wayfarers in windless and dark bush. In Canada mosquitoes are virulent in woods, and Americans say that they are frequently bitten in verandahs and gardens.

adequate powers by law, and were indeed created. Friendly representation to the powers that be will generally suffice, especially if sweeping and costly measures are not advocated—and such will seldom be required. As the citizens begin to see the sense and value of the work the municipality will begin to take it up more and more. If it remains refractory, petitions to government and quiet letters to influential papers will soon remove its opposition. As I said before, the great thing to do is to make a beginning; and the work is of such a nature that, once begun, it is not likely to be dropped, unless the local intelligence is very much below par.

After the original work has been completed, the bulk of the old pots and tins removed, the gutters straightened out, and the pits filled up, it will be necessary only to employ enough men to maintain this happy state of affairs. As estimated in paragraph 12, a dozen men ought to keep 5,000 houses free of *Culex;* but it is more difficult to make an estimate regarding the number of men required to exclude *Anopheles.* This will depend upon the rainfall, the soil, and the perfection of the drainage system employed. One thing may be accepted as certain: no drainage system can be made which will not require the constant services of a maintenance gang to keep it in repair. This maintenance gang will, in the end, become the permanent *Anopheles* gang of the town; and it should be directed by the municipal engineer under the supervision of the health officer. Finally, it is to be hoped that the whole of the business will fall into the hands of the last official. I should recommend, however, that if possible the permanent *Culex* gang be still paid for by voluntary contributions—just to allow the public to have a say in the matter.

Those who may despair of such a pleasant consummation ever being reached should remember that not much more than a century has passed since the usual mode of disposal of slops, adopted by householders in civilized Britain, was to empty them out of the windows on the head of passers by. The employment of sewage drains was inaugurated by private enterprise, and has only gradually come within municipal control. Similarly, the time will most assuredly arrive when it will be just as hard to find myriads of mosquitoes being bred in the streets and backyards in civilized towns in the tropics, as it is now to find slops being poured out of windows in English ones. Private enterprise has begun the campaign in Sierra Leone; but in Lagos and Havana government has already taken it up; and in the latter city we have even the consolation of noting in an official report that "the mayor has issued an order prohibiting the keeping of standing water anywhere within the city limits, unless made mosquito proof."*

If I have spent so much space in discussing the ways and means by which private enterprise can begin this novel kind of warfare, it is only because I am convinced that this is the best way of beginning it; and that where private enterprise leads, public enterprise must and will follow.

* Report of Vital Statistics of Havana, May 1901. In Sierra Leone, the Governor, Sir Charles King Harman, has given us every possible assistance and encouragement.

SUMMARY.

17. Summary of Objects :—

(1). We do not propose to exterminate mosquitoes in any entire continent.

We propose only to deal with them in the town in which we live, and in its suburbs.

(2). We do not propose to get rid of *every* mosquito even in this town.

We aim only at reducing the number of the insects as much as possible.

(3). We do not think it possible to drain or otherwise treat every breeding place in the town.

We aim at dealing with as many as possible.

(4). We cannot exclude mosquitoes which may just possibly be blown into the town from miles away.

We content ourselves with preventing the insects breeding in the town itself.

18. Summary of Methods :—

(1). We start work at once with whatever means we can scrape together.

(2). We operate from a centre outwards.

(3). We clear houses, backyards, and gardens of all rubbish; empty tubs and cisterns containing larvæ, or destroy the larvæ in them by means of oil.

(4). We show people how to do these things for themselves, and how to protect tubs and cisterns by means of wire gauze.

(5). When we have cleared as many houses as we determine to deal with, we clear them over again and again.

(6). We fill up or drain away all the pools, ditches, old wells, and puddles we can—especially those which contain most larvæ.

(7). Such pools as cannot be filled up or drained are deepened and cleared of weeds, if they contain larvæ.

(8). Streams and water courses which possess larvæ are "trained."

(9). Where we can do nothing else we destroy the larvæ periodically with oil, or by brushing them out with brooms, or by other means.

(10). We endeavour to interest our neighbours in the work, and to educate the town into maintaining a special gang of men for the purpose of keeping the streets and gardens absolutely free of stagnant, mosquito-bearing water.

19. **Motto.**—Our motto should be one which I think will shortly become the *first law* of tropical sanitation, namely—

No Stagnant Water.

MISCELLANEOUS REMARKS.

20. **Where not to start Mosquito Brigades.**—I now make some general remarks concerning matters of importance. I have left them to the last, not because the matters are of less moment than those already dealt with, but because the reader will not be able to consider them until he has first learnt exactly the scope and nature of the work proposed to be done.

In the first place, we must understand that there are certain localities in which it will scarcely be profitable to commence a war against our winged enemies. These are mainly as follows:—

(1). *The Open Country.*—We cannot go to the expense of draining large tracts of open country far from habitations, merely for the comfort of the beasts of the field.

(2). *Isolated Houses.*—Except in a dry country, where there are very few breeding pools, or unless we have plenty of labour at our command, it will generally be unprofitable to attempt to drain round isolated houses. The cost of the drainage may often exceed the value of the house; take for example a travellers' rest-house, a railway station, or farm, situated in the midst of marshes or of dense tropical forest. In such cases it will generally be much cheaper to protect the whole building by wire gauze screens to the windows and doors. At the same time, of course, it is always possible to prevent *Culex* larvæ from breeding in cisterns and tubs in the back premises, even of the most isolated houses; and also to sleep under mosquito-nettings.

(3). *Native Towns and Villages.*—Unless Europeans are present in towns and villages, mosquito gangs will scarcely be possible; because in the first place there will be no one to direct them, and in the second place there will be no one to pay for them. I fear that we shall generally have to leave small native towns and villages to their fate for the present, unless there is a much more marked advance of civilisation than we can observe at present, or unless some one comes forward to provide the money required.

(4). *Travellers' Camps.*—Unless the camp is intended to be permanent and labour is abundant, it will generally be waste of time to drain the surrounding area.

21. Where to start Mosquito Brigades.

(1). *Isolated Houses* where the pools are few and labour is abundant, and where white men live.

(2). *Plantations*, *Mines*, and *Farms* where white men live and labour is abundant.

(3). All *Settlements* where white men live in any numbers. Especially *Large Towns.*

Considering these principles, we shall observe that it will generally be advisable to start a campaign against mosquitoes wherever the *game is worth the candle.* The expense of draining a square mile of country may be just as great when that square mile contains one house as when it contains a thousand. But in the first case the expense will be incurred in order to protect only one house; in the second case in order to protect a thousand. Hence we arrive at the following general rule:—*The greater the density of the population the greater the necessity for measures against mosquitoes.*

Other points to be taken into consideration are the relative importance of the locality, the presence of industrial institutions, governments, soldiers, railway centres, and so on. White men suffer more severely from malaria than native adults usually do, and therefore demand more active measures against mosquitoes.

Lastly, it will generally be much more easy and cheap to get rid of mosquitoes in a dry locality than in one in which the ground is water-logged for a considerable part of the year.

In deciding upon the advisability of inaugurating a campaign against mosquitoes, we must be guided by the following principles:—

(1). *The effort should always be made in every town of*

importance, no matter how great the difficulties; because we can count at least on greatly reducing the insects, even if we cannot exterminate them completely; and because in dealing with a densely populated area, the smallest effort will do good to a large number of people.

(2). *In small towns, villages, plantations, mines, and isolated houses, we must be guided by local conditions.* Where there are numerous white men, where the pools are few and easily dealt with, and where sufficient funds are available, a mosquito brigade can be started at once. Where these conditions do not exist it may often be better to adopt other measures against Mosquito-borne disease (paragraph 22).

Finally, I must protest against the idea that it is impossible to reduce the number of mosquitoes *anywhere*—even in the most water-logged locality. Until the experiment has been tried—not perfunctorily, but adequately and persistently—and has failed, we are not entitled to entertain this idea. Indeed, in one of the worst places, Freetown, the experiment is now actually succeeding; and it is my opinion that there is no place in the world where mosquitoes cannot be very greatly reduced in number, if only enough money is spent on the job.

22. Other Methods of Preventing Mosquito-Borne Diseases.—Three diseases are known to be carried by mosquitoes, namely, elephantiasis, malarial fever, and yellow fever. In all, the manner in which the mosquito acts is the same. The diseases are really due to small parasitic organisms which live in the blood,* and which, when the blood is sucked from a patient by a mosquito, exist in the insect for

* We know this by inference only in the case of yellow fever.

a time, and then, when the insect bites a healthy person some weeks later, enter *his* body and set up the infection in him. The mosquito thus acts as a carrier or go-between; and merely conveys the poison from the sick to the healthy, just as the lancet of a vaccinator conveys the vaccine from the arm of one child to that of another. This seems strange to the uninitiated; but it is a commonplace with pathologists. Several diseases of animals are carried by insects in a similar manner; for instance, the famous African disease of cattle which has long been known to be communicated by the tsetse-fly. These facts enable us to prevent mosquito-borne diseases by more than one method, as follows:—

(1). By getting rid of mosquitoes.

(2). By preventing mosquitoes from biting patients.

(3). By preventing mosquitoes from biting the healthy.

(4). By killing the parasitic organisms in patients.

(5). By living at a distance from people who are likely to have the disease.

All these methods are more or less effective; but some are much more practicable under certain conditions than others are. Let us now study the question.

23. **A Comparison of these Methods.**—I have already described the means of *getting rid of mosquitoes*. The measure requires an initial outlay of money, which may be small or large according to local conditions and the thoroughness of the operations—small when the pools are few and easily drained, larger when marshes, streams, and ponds have to be dealt with. Besides the initial outlay, an annual expenditure for a maintenance gang must be incurred—amounting to the cost of fifty men for a town of ten thousand houses, as a very rough estimate. A cost

of something like one or two shillings per house per annum ought to cover these expenses.

The advantages of the measure are (1) that it will protect all persons, rich and poor, living within the area of operations, and will guard them from all mosquito-borne diseases simultaneously; (2) that, in addition to its sanitary advantages, it will preserve people from the constant annoyance due to the insects; (3) that it will necessitate the town being kept in a generally clean and wholesome condition; (4) that it can be effected by the municipality, or even by private persons, regardless of the prejudices or apathy of the householders, who, moreover, will not be put to any appreciable expense on account of the operations.

Protection against the bites of mosquitoes, both for the sick and the healthy, demands (supposing the mosquitoes themselves are left alone) the scrupulous use of mosquito-nets during sleep, and, to be more secure, the employment of wire-gauze screens to all the windows and doors of a house, and if possible the use of punkahs for Europeans. The disadvantages are (1) that a mosquito-net costs from ten to twenty shillings; while to fit a whole house, even a small one, with wire-gauze screens would cost about five to ten pounds, or much more; and the constant use of a punkah could not be obtained, even in India, under about twelve pounds per annum; (2) that the vast bulk of the population, at least in any town in the tropics, could not afford such luxuries; (3) that, as people cannot legally be compelled to adopt these measures, the latter will simply not be attempted even by many of those who can afford them; (4) that people who scrupulously avoid mosquito-bites in their own houses will be apt to become infected when they visit less careful neighbors; (5) that nets and

screens will certainly be frequently left open; (6) that there will be constant disputes between house-owner and tenant as to which shall supply the mosquito-screens;* (7) that screens and nets check the cooling breezes which are so necessary in very hot climates.

Another method for controlling malaria is the one recommended by KOCH, namely, *the destruction of the parasites in man by quinine;* so that the *Anopheles*, even if they exist in swarms, no longer become infected from patients, and consequently do not in their turn infect healthy persons. This method has the double advantage of curing and preventing the disease at the same time; but it has many drawbacks. (1) The treatment is not likely to be successful unless large doses of quinine are taken regularly for at least three or four months under skilled medical advice. (2) In order to stamp out the disease within a given area, it would be necessary to treat all the patients within that area. (3) In a town of, say, 30,000 inhabitants, where half the children and many of the adults are infected, as in Freetown, the cost of providing the requisite medical staff and the drug itself (quinine) would be very great.† (4) Under British law it is impossible to force people to take any prophylactic drug, and we may be sure that nine-tenths of the people in any British colony would absolutely refuse quinine. (5) Quinine does not cure yellow fever or destroy filariæ;

* In the tropics, most Europeans rent their houses from rich natives, who seldom care to spend a penny on their property, and will not generally be induced to provide wire screens. Hence the tenant will have to do this for himself. Since houses are generally taken by the month or quarter, few tenants will be found willing to incur the cost.

† I am informed that in Lagos the animal quinine bill alone will amount to £500 a year.

hence this method would protect against only one out of the three mosquito-borne diseases.

Segregation of Europeans is the last measure recommended, and is evidently an excellent one as regards all diseases. The good health enjoyed by the British in most Indian stations is probably largely due to the fact that they live apart from the natives in separate cantonments. Unfortunately segregation will in many cases necessitate the construction of fresh settlements at a large cost; it will protect only the persons who are segregated; and then only if such persons absolutely refrain from going into other parts of the town.* It will often be very difficult for business men to adopt this measure.

If we study these remarks carefully we shall scarcely fail to be convinced that for large towns, at least, the extirpation of mosquitoes is the measure which presents by far the greatest advantages. It is, indeed, probably the only one which will be ultimately found practicable for reducing mosquito-borne disease on a large scale in towns; and, in fact, the good effect of drainage against malaria has been known for generations. The other methods are more partial and probably much more expensive in the long run. They possess, moreover, one almost fatal defect: while the extirpation of mosquitoes can be undertaken by the authorities without reference to the wishes, convictions, or prejudices of the public, the other methods must depend upon these very quantities. Mosquito-nets, quinine, and segregation will not be generally resorted to until the public generally believes that mosquitoes cause disease. Now I think that I am right in saying that at present, in spite of

* In West Africa it is probable that many of the worst infections are acquired by Europeans in the houses of natives. *Verbum sat sapienti.*

the overwhelming proofs that have been given against the insects, not five *per cent.* even of Europeans in our tropical colonies believe in any such thing. As for natives, probably not one *per mille* has ever heard of the subject.* The complete ignorance which prevails regarding pathology, even among people who imagine themselves to be well educated, and that peculiar apathy which leads thousands of people to prefer "taking the risk" to "taking the trouble," will surely prevent any general personal prophylaxis against mosquito-borne diseases, probably for scores of years. Let us take for example the case of vaccination, and remember that even now, more than a century after JENNER'S discovery, perhaps a tenth of the so-called civilised people of the world disbelieve in it, while cranks still write against it in the press of the day. No; if we wish to clear out mosquito-borne disease on a large scale, we must not wait for the conversion of the public; we must adopt general measures which can be executed without deference to private opinions.

Of course where operations are not likely to be profitable (paragraphs 20 and 21), we must fall back on other measures. Wire-gauze window-screens will be specially useful in isolated buildings, such as travellers' rest-houses, railway stations, and planters' houses; while as regards areas under government control, such as barracks, hospitals, and gaols, or areas under the control of companies, such as large plantations, mines, and so on, all the measures given above can be undertaken simultaneously.

It is not necessary to dilate further on these points.

* Such at least is my experience in West Africa.

The intelligent reader will be able to think out further details for himself.*

It is often stated that we should employ not one but all possible measures. This is not practical advice, because as a rule funds will not suffice for more than one measure. Where they do, then, of course, we can render ourselves doubly and trebly secure if we please. I think that if funds permit, after we have started our mosquito brigades, we should endeavour to add KOCH'S principle, and make arrangements for supplying quinine to the people—at least for the prevention of malaria. The best way of doing this would be to appoint street vendors of the drug. It is possible that enough profit could be made in this way to pay expenses. Then, again, rich people should be persuaded to employ wire-gauze screens, and in the tropics mosquito-nets, punkahs, and segregation should *always* be adopted wherever practicable. The two former should on no account be abandoned, however successful the operations against mosquitoes may have been. Mosquito-nets will always exclude, not only stray mosquitoes, but many other insects; and punkahs keep the body cool, comfortable, and vigorous.

24. Probable Effect of Anti-Mosquito Measures on Mosquito-borne Disease.—Yellow fever consists of a single illness followed by more or less immunity from subsequent attacks. Hence we may expect that the disease will immediately disappear in a given town as soon as we extirpate the mosquitoes there; and this has actually

* Some of the schemes given above have been advocated by persons who are not very familiar with the practice of tropical sanitation. In Italy screens and quinine have been chiefly used; but some writers forget that in the tropics we are not called upon to deal with such civilised and intelligent people as live in Italy.

happened in Havana, where the chief sanitary officer, Major GORGAS, reports that the disease has been practically stamped out as the result of the vigorous campaign against mosquitoes.*

But the case will be somewhat different with elephantiasis and malarial fever. Both these diseases are lingering ones, in which the parasites remain alive for years after the first moment of introduction by the mosquito. In malaria, relapses continue for a very long time after the patient has removed to a completely healthy climate, such as that of Britain. Elephantiasis is a permanent disease due to mischief caused by the parasite. It is obvious, then, that even after we destroy all the infective agents in a town, still people who became infected before we took this action will continue to suffer from elephantiasis, and from relapses of malaria, long afterwards. In other words, while yellow fever will die out at once, malaria and elephantiasis will die out much more slowly. Hence the extirpation of mosquitoes will not produce as sudden and marked an effect on the two latter diseases as on the first. Indeed, except in the case of newcomers and children born after the operation, not much effect is likely to be manifest in the case of malaria under several years, and in the case of elephantiasis under many years (that is, until the majority of the patients have died). We must not, therefore, expect to see malaria vanish, as if by magic, immediately after our campaign against mosquitoes. Certainly bad out-breaks, such as those which often occur among soldiers and labourers, ought to cease fairly abruptly, provided that the areas concerned have been properly dealt with; but

* Report for September, 1901—Appendix.

old cases will still linger on, and old residents will continue to suffer from their weekly or monthly "go of fever." Of course, sceptics will point to this continuance of the disease and will claim that it disproves the mosquito theory; but this will not be a fair argument, for the reasons just given.

On the other hand, as soon as the mosquitoes are appreciably reduced in number, we may reasonably expect a parallel reduction in the number of *fresh infections*. In very malarious countries, almost all the resident adults have been infected at one time or another; so that the appearance of fever in these is often due to relapses. Hence, in such localities, we can only gauge the number of fresh infections in people who arrive from non-malarious countries, and in newly born children. The latter will afford an excellent means of judging the decrease of malaria by an accurate process. KOCH discovered that in malarious places a very large percentage of the native children possess the parasites of malaria in the blood, even a few months after birth. If, then, we can show that this percentage decreases after our operations against mosquitoes, we shall be able to prove the good effect of the measure by an exact method. The method is one, however, which can only be employed by a well-instructed medical man.

Less accurate methods consist in examining the enlarged spleens of the children before and after the operations; and in noting the decrease of fresh infections in newcomers. For the latter criterion it is, of course, necessary that the newcomers examined have not left the area of operations since their arrival, because otherwise they may have contracted the disease outside.

The gradual decrease of admissions and attendances for malarial fever in hospitals, especially in the out-patient departments, will be another criterion; but it will be a good one only if the hospital records have been kept with due care and skill.

All these tests for the decline of malaria will require the services of medical men—and of well-trained medical men. It is always a very difficult matter to form any numerical estimate of the *amount* of malaria in a given locality, and, consequently, of variations in that amount. In any town where it is proposed to organise mosquito brigades the laity should be made acquainted with these facts, and should be carefully warned against forming conclusions on hearsay evidence or inexpert opinion.

In the meantime we may continue our labours in serenity, and with an absolute assurance that the diminution of mosquitoes will ultimately lead to a diminution of all kinds of mosquito-borne disease.

It will be scarcely more easy to gauge the decrease in the number of mosquitoes than to gauge that of malaria. Perhaps the best plan will be to employ the mosquito-trap described on page 11. Persons should be induced to sleep nightly at different spots in mosquito-nets with several holes in them; to count in the morning all mosquitoes which have entered during the night; and to keep a careful record of the observations made. If a marked decrease occurs and is maintained, it will be safe to argue that the insects have decreased *at the spot where the experiment is made.* Perhaps, however, the most reliable evidence upon this point will lie in a general consensus of opinion

on the subject. We must always, however, guard against the sudden appearance of large numbers of mosquitoes in single houses. People should be warned to report such cases at once. Of course it will generally be found that the insects come from some vessel or pool of water lying in proximity to the affected house, and overlooked by the mosquito gangs.

It may now be asked, what percentage of diminution in mosquito-borne disease may be expected to follow a given percentage of reduction in the number of mosquitoes? I regret that I cannot as yet give any actual statistics on the point, but we may perhaps attempt an estimate on *a priori* grounds. We ask, are we to expect a decrease in disease in the same ratio as the decrease in the number of mosquitoes; or in a duplicate ratio? The disease will probably diminish in a duplicate ratio.

Suppose that in a given locality one in every thousand mosquitoes is infective; then, roughly, one in every thousand bites suffered by the people will be infected bites. Now, if we reduce the number of mosquitoes in the locality by one-half, the mosquito bites also will be reduced byone-half; and, consequently, only half as many people will now become infected as was formerly the case. But, since the mosquitoes themselves are infected by biting previously infected persons, the percentage of infected mosquitoes, among the insects which remain, will also be reduced in its turn, because the insects will now find fewer infected persons to bite. Hence, ultimately, the number of infected persons in the locality will be reduced by much more than one-half. In fact, we may perhaps assume that the number of infected persons will be reduced to one-quarter—that is,

in the duplicate ratio of the percentage of reduction of the mosquitoes. Similarly, if we can reduce the mosquitoes to one-tenth, we may hope to reduce the mosquito-borne disease to the one-hundredth part of its former prevalence. *I think that this degree of reduction will always be possible.*

25. **Sanitary Anarchy.**—In conclusion, it will be asked, why is it that such measures as draining and cleaning up towns must ever be commenced by private enterprise; surely the matter is one which lies in the province of the public authorities—who ought to attend to it at once, especially in view of recent discoveries regarding mosquitoes. The Imperial Government of Britain possesses an enormous medical and sanitary machinery, the branches of which extend into even very small towns in our tropical dependencies—a machinery which costs the country a heavy sum of money; why can it not be set in motion by a word from headquarters; why cannot the host of medical and health officers, of sanitary engineers and inspectors, all paid out of public moneys, be directed to commence the obviously necessary improvements indicated above?

In Cuba, no sooner was the mosquito proved to be the disseminating agent of yellow fever than, without delay or hesitation, the local sanitary staff was *ordered* to commence the obvious remedy—the extirpation of mosquitoes.* Hence it can scarcely be denied that such vigorous action is at least *possible.*

* Major Gorgas reports September, 1901, "As to yellow fever, there has never been an approximation to this condition (the freedom of Havana from the disease) at any time in the last 150 years. This is the first year, during that period, in which we have known that yellow fever was conveyed by the mosquito; and, during February, the Military Governor directed that our disinfection be carried out on these lines. I attribute our very surprising results to this fact." *See* also the campaigns at New York in the Appendix.

But the British authorities are made of different stuff. They love to ponder things. They will go on pondering for twenty years. It is twenty years since MANSON proved that mosquitoes carry elephantiasis; but I believe I am right in saying that in not a single spot in the whole of the British dominions has a single effort been made during all this period to control this disease on a large scale by means of MANSON'S discovery. The mosquito-malaria theory has been fully established for nearly three years; but, except in Hong-Kong and Lagos, I doubt whether the authorities have yet saved a single life by attention to its teachings.*

The fact is that the Imperial sanitary and medical services of the country are very badly organised. They are held rigorously under the thumb of the soldiers, lawyers, tax collectors, and politicians who manage our public affairs, and most of whom care little for sanitation, and certainly know nothing about it. This seems a hard thing to say, and certainly there are exceptions (*e.g.*, the governments of the West Coast of Africa *now*); but the statement is mainly true, and I speak from twenty years' experience of the matter. There is no skilled and responsible head empowered to direct and enforce even the most obvious movements in connection with our Imperial sanitary and medical services. It is disgraceful that in scientific matters, concerned with the life and death of thousands, scientific men should be so absolutely subordinated to unscientific men. Gross defects exist also in the executive of these services. The many able and energetic men whom they possess are disgusted by the absence of scope for their powers or recognition for their

* Twenty years elapsed before LAVERAN'S discovery was generally used in our tropical hospitals in the diagnosis and treatment of fever.

services; while, on the other hand, the most perfunctory, incapable, and out-of-date officials seem generally to rise by the mere *vis inertiæ* of their apathy, so congenial to their surroundings, and continue to rise in spite of the gravest incapacity.* Under such a condition of anarchy it is hopeless to look for any immediate concerted action against mosquitoes from the public sanitary services; and it is for this reason that I have so frequently appealed in the present work to the initiative of private enterprise. It is public opinion alone which has created the sanitation of civilised countries; and it is only public opinion which will enforce sanitation in the tropics. Sensible men living in countries which are persecuted by mosquito-borne diseases should remember these facts, and should endeavour to further the cause of prevention, not only by constant agitation, but by their own personal exertions made in the manner I have indicated in the first part of this book.†

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* A great deal of the opposition experienced by recent discoveries in connection with mosquito-borne disease is due to such people, whose real object in making the opposition is to save themselves the trouble of acting on the scientific information obtained.

† I fear that these remarks will offend some; but no one who has seen the shocking condition, even of some capitals of British Colonies, or who has as much experience of tropical sanitary organisation as I have, will deny their truth. If one feels called upon to write at all on sanitary matters, he must not fear to write exactly what he thinks is the truth. Sanitary matters are not only matters of life and death to whole communities, but they are often connected with the entire welfare of whole countries. Here then, if anywhere, a man has the right to speak out, regardless of the susceptibilities of persons who may consider themselves injured by his remarks.

The usual excuse given for bad sanitation is, of course, want of funds. But this rarely prevents money being poured out in other channels less useful to the taxpayers, but more congenial to those who regulate the budget. It is high time that there should be fewer officials and lawyers, and more doctors and business men, in the councils of our colonies. Doctors, also, should be more frequently made mayors and chairmen of municipalities.

Fortunately there is now strong evidence of a great improvement in the attitude of government towards tropical sanitation; while the dedication of this book will convince the reader that influential people at home have begun to take a lively interest in this important matter. With this combination much will be done in the future.

APPENDIX.

HISTORY OF THE WAR AGAINST MOSQUITOES.

The connection between mosquitoes and *elephantiasis* was discovered in 1880 by MANSON. In 1900, JAMES and LOW discovered that the parasites, sucked from the blood of patients by the mosquito, finally enter the proboscis of the insect in order to return into a fresh human being; so that mosquitoes simply convey the parasites from the sick to the healthy.

The story of *malaria* is briefly as follows:—LAVERAN discovered the parasites of this disease in 1880. Subsequently several people independently conjectured that mosquitoes carry these parasites also—namely, KING in 1883, KOCH in 1883–4, LAVERAN in 1884, MANSON in 1894, BIGNAMI in 1896, and others; but it must be understood that these scientists did not go beyond conjecture, or at the most hypothesis.

The fundamental facts regarding the life-history of this group of parasites in the mosquito; the proof of the mosquito-theory of malaria; the first determination of the kind of mosquito which carries human malaria, and of other facts of leading importance in this connection, were obtained solely and simply by my researches of 1895–99.* I regret that I am forced to make such a boastful statement; but the fact is that the constant misrepresentations to which the public has been treated in this matter leaves me no option but to do so. I must add also that, while my work was based on the admirable hypothesis of LAVERAN and MANSON,† the execution and completion of it were my own. These researches were confirmed and amplified by KOCH and DANIELS in 1898–9, and by ZIEMANN, CHRISTOPHERS, STEPHENS, MANSON, VAN DER SCHEER, VAN BERLEKON, NUTTALL, RUGE, ANNETT, JAMES, FERNSIDE, and many

* *See* LAVERAN, *Bull. de l'Academie de Médecine*, 31st Jan., 1899; KOCH, *Zeitschrift für Hygiene*, Bd. 32, 1899; Lord LISTER, *British Medical Journal*, 8th Dec., 1900; and *Times*, 19th Sept., 1901.

† *See* my *Malaria and Mosquitoes.*

others since then. In 1897, MACCALLUM discovered a most important fact in the life-history of the parasites. In 1898–9, BASTIANELLI, BIGNAMI, and GRASSI ascertained the genus of the mosquito (*Anopheles*), which I had previously proved to carry malaria in India, and found in similar insects in Italy the stages of the development of the parasites previously described by me. I regret that I must add that, for the rest, the writings of these three persons, especially of the last, constitute one of the most impudent scientific piracies on record, and are little to be trusted except when directly based on the works of more reliable observers.*

Regarding *yellow fever*, FINLAY, of Havana, has long held the hypothesis that the disease is conveyed by mosquitoes. The fact has been recently quite conclusively proved by LAZEAR, CARROLL, REED, and AGRAMONTE, by direct inoculation of the disease in a number of persons, by means of mosquitoes fed twelve or more days previously on patients with the disease. LAZEAR, who was bitten in this manner, died. Attempts to infect numerous persons by means of the clothing of patients, and by other methods, all failed.†

As soon as the exact method of infection in malarial fever was determined, it became at once necessary to attack the question of prevention in the light of the new discovery. I recommended, over and over again,‡ the principle of the extermination of mosquitoes in towns, advocated above, but without succeeding in persuading my countrymen to adopt it; though, in 1899, I went with Dr. ARNETT and Mr. AUSTEN to Sierra Leone to make a thorough local investigation of the subject.§ Meantime KOCH, with great energy, attacked the same question in certain German tropical possessions; but he recommended another method—that of cinchonising whole communities. Simultaneously the Italians employed KOCH'S method, together with window screens; and MANSON clearly demonstrated the value of the latter by his Campagna experiment of 1900. In our Sierra Leone report we had mentioned the advisability of segrega-

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* The facts as regards priority have been impartially marshalled by NUTTALL, in the *Quarterly Journal of Microscopical Science*, May, 1901. *See* also my letters in the *Policlinico*, Rome, Nov., 1900, and May, 1901.

† *New York Medical Record*, 16th February, 1901.

‡ Letter to Government of India, partly published in *Indian Medical Gazette*, July, 1899. Also *British Medical Journal*, 1st July, 1899; *Lancet*, 1900, vol. II, page 1400; *Journal of Society of Arts*, 30th November, 1900.

§ Memoir II. of the Liverpool Tropical School publications, 1899.

tion for Europeans in the tropics; and CHRISTOPHERS, STEPHENS, ARNETT, DUTTON, and ELLIOTT strongly advocated this idea.

I will not dwell upon these points any longer because this work is not exactly concerned so much with the prevention of disease as with the extermination of mosquitoes; but I shall now give extracts from the descriptions of their own labours, written by several capable workers. These extracts will be found very useful by the reader who wishes to make similar efforts himself.

The campaigns are described in the order in which they were undertaken, beginning with that of YOUNG and THOMSON and concluding with that of the Liverpool School of Tropical Medicine in Sierra Leone. Doubtless many small campaigns have been undertaken by individual medical men. I do not refer to all of these because I do not possess full accounts, or because (in some cases) they were evidently too perfunctory to be worth mentioning. The Havana and Freetown campaigns seem to be the only ones carried out on a large scale and based entirely on the extermination principle. If I have overlooked any work in this line, I hope that those who have done the work will send me details for insertion in future editions.

An excellent American work on Mosquitoes, by L. O. HOWARD, has just come into my hands when completing the proofs of this work. It contains accounts of several interesting American campaigns. Owing to the shorter summer, the use of oil is likely to be more efficacious in the temperate parts of the United States than in the tropics. Mr. HOWARD gives many interesting stories of mosquitoes in America, which suggest that the habits of the insects in cooler regions are somewhat different from their habits in the tropics. Of course, campaigns against mosquitoes in civilised countries will always be much easier than campaigns in the tropics.

The Prevention of Malaria in Hong Kong, by J. M. YOUNG, M.B., F.R.C.S.Ed.*

The prevalence of malaria in the island of Hong Kong has not only been demonstrated by finding the various types (both benign and malignant) of the malarial parasite in the blood of patients, but also by whole districts mapped out as notoriously unhealthy, houses after

* *British Medical Journal*, 1901, vol. II., page 683.

being built standing uninhabited, whole terraces unletable, and having to be pulled down, because of the amount of fever from which the inhabitants suffered. For six months under the military and civil authorities I made extensive experiments over considerable areas, with the object of finding out the cause and making suggestions as to the prevention of malaria.

Alike from adult mosquitoes secured and examined and from larvæ collected from various breeding pools and developed in captivity two distinct varieties of *Anopheles* are abundant—*Anopheles costalis* and *Anopheles sinensis*, and nearly a dozen distinct species of *Culex*, the proportion of *Anopheles* varying in different localities.

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The localisation of the various *Anopheles* breeding pools around twenty selected districts where malaria had distinctly and repeatedly manifested itself gives some important information as to the range of an infected area from a given nidus. From these I have chosen six, of which I give full details and measured distances, with rough sketch maps.

1. THE MILITARY SANATORIUM.

An isolated building, with accommodation for two companies and officers' quarters, situated on the hillside above Hong Kong City. The history of this building is most instructive. Three years ago, owing to the presence of malarial fever of a most malignant type (80 per cent. of the last company sent there being down with malaria) the building had to be closed. This valuable property had assumed a most deserted appearance, the trees, shrubs, and grass having grown up all over the hillside.

After carefully examining the various streams around, the haunts and breeding places of *Anopheles* were very distinctly localised; many adult *Anopheles* were captured, and the discovery of dozens of their breeding pools within a few hundred yards of the sanatorium made me safe in pointing out the cause of the notorious name which this building had acquired and in suggesting the remedy, by destroying them in the bush and preventing others from breeding in the pools and bogs around. In the immediate vicinity of this building numerous bogs of mud and rank grass, with an aggregate area of not less than half an acre, exist; these bogs lie hidden in the hollows of the hills, and nothing could be more like African fever swamp. These

forming with the luxuriant vegetation around the best nidus for the development and subsequent life-history of mosquitoes. (Within 80 yards of the main building with an ordinary teaspoon I scooped up four *Anopheles* larvæ at one time.)

The officer commanding (General Gascoigne) having given me full liberty and granted 150 Indian troops of the Hyderabad contingent, we began by clearing the hillside, working out from the main building, cutting and burning absolutely the undergrowth and tangled creepers —this for a distance of 300 yards occupied the men for a period of two months. The bogs and pools were then drained by ordinary surface draining, and for a period of at least two years this area is to be kept rigorously free from the dense impenetrable undergrowth. The health of the troops has remained good during the whole time, and the building is now inhabited by white soldiers.

2. LYEMOON BARRACKS.

A modern building situated 200 feet above the sea, on the hill commanding the Northern Pass to Hong Kong Harbour. The persistent outbreaks of fever and the almost continuous stream of patients sent to hospital from this building rendered the question an extremely important one to the military authorities.

On the north side, nestling in the hollow of the hills, I found numerous pools and small bogs in which were hundreds of larvæ of *Anopheles*, especially in and around the rice fields cultivated by the Chinese, in one case within 80 yards of the barracks.

On the west side, 180 yards from this building, is the police station and Chinese village of Sakiwan, which have been free from malaria. Mosquitoes have been regularly collected by the police, no *Anopheles* have been caught, and no "fevers" are reported among the native police or in the village of 1,500 population. Thus the distribution of *Anopheles* conforms accurately to the history of the outbreak of malaria, as, after exhaustive search, I was unable to find one breeding pool with *Anopheles* larvæ round Sakiwan.

3. MARRIED MEN'S QUARTERS, KENNEDY ROAD.

A magnificent new building, only opened a year ago in July. The rooms airy and all modern conveniences, little or no malaria in the district. Unfortunately the builders left rubbish and pools lying

around the house. In one of these artificial ponds were hundreds of larvæ of *Anopheles* within fifty yards of this building. There were no *Anopheles* in the surrounding streams when I examined them in August. After a time these pools were filled up and drained, but before that hundreds of adult *Anopheles* must have developed and were then living in the bush ; they were secured in and around the building. Note what occurred. When the *Anopheles* were driven from their breeding pools they took the next best pools, and I found them in December in the streams around, in pools which I had examined three months before with a negative result. Then gradually the children began to have feverish attacks, and the inhabitants of the houses around complained, the Women's Military Hospital became crowded with patients, until within six months of the opening of this building out of 73 women and children 33 per cent. had fever, of the children under 10 years 50 per cent., and unfortunately there were 3 deaths to record ; and in a few selected cases among the children the blood under microscopic examination contained parasites.

4. POKFULAM.

The French Fathers sixteen years ago bought property for schools and training colleges, which four years later, owing to almost continuous attacks of fever and the sad loss of life therefrom, they had to relinquish at considerable loss and remove to another site about half a mile from the old place ; again, in another building occupied by Madame Musso 300 yards further west, fever has been common. In the present building occupied by the Fathers and 150 children they have had little or no malaria ; and on the most careful examination I was unable to discover one larva of *Anopheles*, while in and around the old site and around the house occupied by Madame Musso I found them breeding in hundreds. As this is the history extending over years, and as the facts conform accurately to the prevalence of *Anopheles* and malaria, it would afford strong presumptive evidence of the distance travelled by mosquitoes over an infected area.

5. MOUNT RICHMOND.

One of the finest private residences in the Colony, originally costing 130,000 dols., was sold for something like 25,000 dols. At the request

of the owner I examined this district, and from the report sent to him I read the following:

"The history you gave me of the various buildings and the prevalence of malaria was most instructive, and from it alone I felt sure that there must be some breeding pools in the immediate vicinity, but I hardly expected to find them so close to the building and so localised. I have to-day taken nearly a hundred larvæ of *Anopheles* from a single pool within 80 yards of your house. I have no hesitation in saying that you could not be without fever, and that this fully explains why for years the district has had a fever-stricken name."

Why is it that within 50 yards of this property, separated by a road and a clear space, other houses were free from malaria, and the inhabitants lived for years in comparative immunity? The cause and effect are so distinctly marked out that I was fully justified in promising the owner a permanent and effective cure which would greatly enhance the value of his property at a comparatively small cost.

6. TAI-PO POLICE STATION.

The following extracts from a report, dated Hong Kong, November 17th, 1900, by Drs. J. M. YOUNG and JOHN C. THOMSON gives the results of an inquiry into the causation of the prevalence of malarial fever at Tai-po:

We have the honour to report, for the information of His Excellency the Governor, that in accordance with His Excellency's instructions we proceeded to Tai-po for the purpose of inquiring into the causation of the marked prevalence of malarial fever there recently.

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We made careful search in all directions around the Government buildings and matsheds for breeding places of *Anopheles*. From the results of our search, we direct attention to two important points: (1) that the breeding pools that proved most important, and which even at this late date in the year contain abundant larvæ, are within 80 yards of the police station, and 40 yards from the matshed occupied by the civil staff; and (2) that the marshy stream above referred to is a permanent and prolific breeding ground.

We examined under the microscope the blood of ten children from the village nearest to the police station.

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In 50 per cent. of the cases examined we found the parasites of malaria; 2 cases were of benign type and 3 malignant, and while

all five children were infective to the mosquito, rendering any *Anopheles* feeding upon them capable of a few days later transmitting the disease to other persons, in 2 cases the form of the parasite that actually came under our observation was the gamete, namely, the form which when ingested by the mosquito is capable of undergoing metamorphosis in the body of that insect.

In the abundance of mosquitoes of the *Anopheles* genus above described, with their breeding grounds almost close up to the Government buildings, and in the near proximity of an extensively infected native population, by which many of these mosquitoes are being continuously rendered infective to healthy persons who may be bitten by them, we have the factors that account sufficiently and conclusively for the fevers that have prevailed among the Government officers at Tai-po.

We are of opinion that the seasonal increase of fever cases that has been observed at the time of ploughing, and at the period of harvesting the two rice crops, is due to the disturbance at these times of mosquitoes usually resting among the grass or growing paddy, and feeding on Chinese coming within their reach, such disturbance resulting in their flying further afield and finding their way in large numbers to the houses on the hills.

I would emphasise the practical impossibility of dealing with the larvæ of mosquitoes by any germicide on account of the hidden nature of many of their breeding places, which were only found after the undergrowth was removed ; and on account of the luxurious vegetation in which the adult mosquitoes live. Culicicides, petroleum gas, lime, gallol, etc., are only subsidiary measures, although undoubtedly useful.

The only permanent and effectual method seems to be that adopted in Hong Kong: (1) clearing all long grass and undergrowth, and then (2) destroying all breeding places by draining, etc. Alike from observation and experiment, I would place a cleared area as of immense importance ; no mosquitoes will fly far without vegetation, and old residents in West Africa have by experience found this out, and regularly burn the bush, and this is over and over again emphasised in various localities in Hong Kong ; even a road intervening made all the difference to the health of a community.

Extensive experiments have been made as to the destruction of mosquitoes and their larvæ by the "natural enemies of mosquitoes," dragon flies, tadpoles, small fish ; the whole subject seems to me of

little practical importance. I have repeatedly put 20 *Culex* larvæ and 20 *Anopheles*, collected from different pools, together. The effect was astonishing. Within twenty-four hours there was no trace of the *Anopheles* larvæ, and like Pharaoh's lean kind the *Culex* did not seem any the fatter for having absorbed them; indeed, no one can realise the intensity of the struggle for existence which goes on in a stagnant pool until he forces himself with a large hand lens to watch the various forms of life with which the water is swarming. *Culex* larvæ, then, are an important factor explaining why in many places where mosquitoes are more numerous there is no malaria, the weaker *Anopheles* being overcome in the struggle for existence.

CONCLUSIONS.

These results, and the details of other places, lead me to the following conclusions:—

1. That malaria, in every place examined, was invariably associated with *Anopheles* breeding pools in the immediate vicinity.

2. That in no case were *Anopheles* found in the neighbourhood of houses without malarial fever manifesting itself repeatedly, that is, where *Anopheles* are found, there is fever, and in every district where there is marked malaria there the blood of children examined contained the malarial parasite, living *Anopheles* were caught and their breeding pools localised.

3. That in no case was there a greater distance from the breeding pools to the houses infected than 150 yards.

4. That the breeding pools were always localised and comparatively easily treated by surface draining.

5. That the only practical steps found effectual were by clearing the district of all shrubs, grass, bamboos, etc., in order to drive away the adult female mosquitoes and then draining their breeding pools; this combination is absolutely essential, to treat the pools with any larvicide alone means that they scatter and select other pools to lay their larvæ and breed from.

In conclusion, these results corroborate recent investigation made by others, and I believe if properly carried out, even over a limited area, would free that district from the haunts of *Anopheles*, and consequently the horrors of malarial fever. It is no Utopian idea to think that within a few years an island like Hong Kong or Stretton Island, New York, may be cleared by our breaking the extra-corporeal life

circle of the malaria parasite. Within the last year I have visited Sierra Leone and seen Major ROSS at work, have seen the experiments at Stretton Island, New York, under Dr. HOWARD, U. S. Entomologist, and I unhesitatingly state that in none of these places would I be more hopeful of the prevention of malaria than in Hong Kong.—*British Medical Journal.*

Notes on Anti-Malarial Measures now being taken in Lagos, by His Excellency Sir WILLIAM MACGREGOR, K.C.M.G., C.B., M.D., Governor of Lagos.*

These few field notes to be read at a discussion on malaria have been written on the suggestion of Major RONALD ROSS. The writer of them is deeply sensible of the honour conferred on him by being asked to prepare them—a request which has very willingly been complied with.

The general outline of the natural history of the malarial parasites is here accepted as sufficiently established for practical purposes by the unique and glorious labours of Major ROSS. In these notes, therefore, only the practical aspects of the question are touched upon.

It may at once be premised that to no other country of the same size is the subject of malaria of greater importance than it is to Lagos. Its economic and industrial future very largely depends on whether malaria can be successfully combated or not. Lagos has been a malaria centre that has earned a very unenviable reputation. It is very favourably situated for commerce; geographically it is the natural port of outlet of the great interior province of Northern Nigeria. It seems clear enough that practically only two things are wanting to make Lagos a great and prosperous commercial town, by far the greatest in West Africa. These two things are the extension of the Lagos Railway to Northern Nigeria, and the control of malarial fever. The two undertakings are in practice closely connected together, and perhaps malaria is not the less important of the two. Both are practicable, but malaria is the more urgent, and therefore

* *British Medical Journal*, 1901, vol. II., page 680.

should be dealt with first. Malaria can also be coped with on a greater or lesser scale in proportion to the means available from time to time. Some of the steps now being taken in Lagos to combat malaria will be mentioned herein, more particularly from the point of view of the administrator.

It may be admitted at once that at Lagos, as probably everywhere else, the academic rules of procedure cannot in any one direction be carried out with scientific minuteness and detail. The measures adopted must be such as can be accomplished by the men and money at disposal; and as these coefficients will very likely not be on the same scale in any two British colonies, the attack on malaria will doubtless be planned out differently according to local circumstances. Were there ample funds at disposal the measures now taken in Lagos would be different from what they actually are at the present time.

It has been felt to be an important preliminary necessity that every effort should be made to acquaint with the general principles of the present malarial doctrine, not only the Europeans resident in this country, but also the natives of every degree of civilisation. For this purpose the reports of Professor KOCH on his Eastern expedition, in which he demonstrates so effectively the specific action of quinine on malaria, have been translated and published in suitable pamphlet form, and have been widely distributed. The same course has been adopted with regard to Professor CELLI'S very convincing report on the use of mosquito netting on the Italian railways. Extracts have similarly been published and distributed from the reports of English expeditions and from other similar English works, including a paper on health read by Dr. STRACHAN, Chief Medical Officer of Lagos, at Liverpool. A short course of popular lectures on malaria and dysentery has been delivered in Lagos by Dr. BEST. These lectures, in which the use of technical terms and phraseology has been carefully avoided, have created a much larger amount of interest, and been far better attended, than one could have dared to hope for. It is contemplated that teachers in public schools, who have diligently attended Dr. BEST'S course, should impart to their scholars the rudiments of the malarial doctrine in a health class, which will be examined by an inspector in much the same way as any other school class, and will count equally with reading and writing for the distribution of the school grant. The Chief Medical Officer is now preparing a general course of lectures on sanitary subjects; and it is intended that these

shall be repeated at different places, in the native language, by one or more of the medical officers that are natives of the country. It is certain that by these means, and by an intelligent appreciation of the vast importance of the subject to this country, a degree of interest in the question has been created in the public mind here that one could not have expected. It is very important that people should at the outset generally understand and believe the theory of malaria. Belief has become more general than one could have foreseen. It is gradually becoming understood.

In active operations the greatest attention is being given (1) to the prevention of malaria by the administration of quinine; and (2) to the use of gauze netting; while (3) at the same time the mosquito is attacked in his breeding ground.

THE ADMINISTRATION OF QUININE.

It appears highly probable that at least as much can be done here by the use of quinine as a preventive as by the employment of mosquito netting.

The greater number of Government officers take quinine regularly, but, of course, so long as taking quinine is not compulsory there will always be a residuum of men that either because they cannot tolerate quinine, or for some other reason, will not use it as a preventive of fever. There are some half a dozen such in this service. This remedy is as much required for native as European officers. In 1900, 79 cases of fever in European officers, of an average duration of 4.5 days, were treated by the medical officers, as against 149 cases of an average duration of 3.4 days among native officers. From January 1st to May 23rd the figures have been 15 European cases of an average duration of 7.5 days, against 47 native cases averaging 3.38 days. This gives a total of 94 European cases and 196 native cases.

Recently no fresh case had occurred in Lagos for nearly a month. Then one case presented itself, and that one case occurred as opportunely for the malaria doctrine as if it had been made to order, for it was in the person of an officer on whom quinine produced its evil effects in an aggravated form, so that he could not take it as a preventive. As a symmetrical demonstration of the theory, a second officer that shared the same quarters should have contracted the contagion from the first one, for the quarters were full of mosquitoes.

But he took much quinine and escaped, thereby illustrating the already proved value of quinine as a preventive.

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The great difficulty is how to extend this preventive treatment beyond the service, more particularly to the uneducated masses of the natives. It is simply impossible to protect the whole population by quinine administered as a prophylactic. In the first place, the great mass of natives would not take the medicine; and, in the second place, the Government could not afford to pay for the 70 tons of quinine a year that would be required to give even a daily grain dose to each of 3,000,000 of people. Quinine as a preventive will not at present be given to natives outside of the town of Lagos. A special vote of £500 has been made for the purchase of this medicine for this particular purpose. A public dispensary already exists in the town, at some distance from the general hospital. At this dispensary between 2,000 and 3,000 patients are treated annually. A second dispensary is being constructed in Lagos, and a third one at the suburb of Ebute Metta. It was felt that this, and the appointment of a special medical officer to attend the poorer natives, would still fail to reach a large number of the indigent and more ignorant. To take up this work a large number of the educated ladies of Lagos have formed themselves into a league, chiefly for the purpose of administering quinine to native children and others suffering from or specially exposed to fever. These ladies are natives of West Africa, but many of them have been well educated in England. It is hoped that they may be able to induce many natives to take quinine that otherwise would simply refuse it. The league is at least an important educational institution.

It is not likely that in a place like Lagos as good results can be obtained from the use of mosquito-proof netting as in Italy. One great objection to it here is the serious and highly disagreeable way it checks ventilation. This is a difficulty that cannot be fully brought home to one in a cold climate. But in a low-lying, hot, and moist locality like Lagos it comes to be a choice of evils to sit inside the netting stewed and suffocated, or to be worried and poisoned by mosquitoes outside. The netting is hardly a feasible remedy as regards native houses. It is not possible to protect even European quarters completely by it. Few officers or others are so occupied that they could spend the day in a mosquito-proof room. Certain it is that any man that suffers from the singular delusion that mosquitoes bite

only during the night would have a speedy cure by spending a few days, or even a few hours, in Lagos. Operations here are being limited to supplying one mosquito-proof room to the quarters of each officer. In this he will be able to spend the evening free from mosquitoes if he chooses to do so. The European wards of the hospital are similarly protected. Hitherto we have used only muslin, as the wire netting ordered in England last November has only just now reached us. Much importance seems to be attached to the question of the material to be used in making the metallic netting, which alone can last in this climate. Muslin becomes full of mildew and rots in a few weeks when exposed.

We have had here a very useful experience as to the materials required for the metallic gauze. In May, 1894, some 250 yards of galvanised wire netting was obtained from England and was used in building rose houses at Government House in August of the same year. Those houses have been examined by the Assistant Director of Public Works, who says they will be good for four years more. This shows a vitality in this climate of some half score years for the galvanised wire netting. The experiment seems conclusive for Lagos, and in future this kind of gauze will be used instead of the expensive article made of compound of copper.

THE ATTACK ON MOSQUITOES.

The measures taken for diminishing the numbers of mosquitoes are various. The most expensive is the slow, laborious, and costly one of filling in the swamps of Lagos. That is being done chiefly by convict labour, but will be much expedited soon by steam power. Meanwhile kerosene is being used on some of the swamp pools most favoured by the *Anopheles*. It is an unfortunate fact that the *Anopheles* is, at least in certain parts of Lagos, the most common mosquito. About 70 per cent. of the many that haunt Government House are *Anopheles*, and unhappily they puncture one all day long.

Many of the water tanks about European quarters are found to contain large numbers of mosquito larvæ. A tinsmith has recently been engaged from England whose first duty it will be to make all water tanks mosquito-proof. It appears from many observations that mosquitoes do not breed in the Lagos wells, though they are seldom over 20 feet deep, while many are considerably shallower. Fortunately for Lagos the town is built on sand, through which rain

pools soon disappear by filtration. But for that accident the place would be simply uninhabitable.

It is strongly recommended in certain competent quarters that to get away from infected mosquitoes Europeans should live at places apart from natives. This may be called the academic view. From the administrative point of view it is an unacceptable doctrine. The academic view is ungenerous, and would afford no radical remedy were it practicable, which it is not. The policy followed in Lagos in this as in other matters is to take the natives along with the European on the way leading to improvement. Here they cannot live apart nor work apart, and they should not try to do so. Separation would mean that little, or at least less, would be done for the native, and the admitted source of infection would remain perennial. To simply protect the European from fever here would never make Lagos the great commercial port that it should become. What we can do in this matter for the uneducated part of the Lagos population will be effected chiefly by reclaiming swamps and administering quinine.

It is a fact that has been impressed on myself in a marked manner during the last few weeks that mosquitoes are much more numerous about European quarters than about native dwellings. Up country there are not a few mosquitoes at every European quarter we put up, while at many native camps there were none. The reason of the difference seems to consist in the tanks and other receptacles for water, and in the greater frequency of pools about the quarters of Europeans, one of the results of greater cleanliness. In the interior, speaking generally, the two places at which mosquitoes most abound are European quarters and the tops of the hills, the two localities at which one would reasonably expect them to be least numerous. The explanation with regard to the residences of Europeans has been given. In the granitic or gneissic hills there are numerous natural fissures, sometimes large numbers of artificial excavations that have served as mortars for grinding corn. In these fissures and excavations mosquitoes breed in large numbers. On the other hand, the low-lying country almost always consists of porous sandy soil through which rain is filtered into a subsoil of gravelly formation. A clay surface along which rain water runs is exceptional. The final result is that for six months in the year the propagation of mosquitoes is practically at a complete standstill in the interior. The soil becomes extremely dry, and remains in that condition for several months. One hardly ever sees a pool anywhere save in the beds of rivers and creeks

of a considerable size. As these latter are full of small fish the mosquito larvæ bred there have extremely little chance of survival. During the dry season there was not a mosquito to be seen at Oloke-Meji, on the Ogun River, a place that one would have expected to be infested with them. It is the sandy porous soil of this country and its long-continued dry season that reduces the number of mosquitoes here to a very small fraction of those met with in a place like British New Guinea, for example. It would perhaps be possible to exterminate mosquitoes altogether in the Lagos hinterland if it were practicable to prevent their production near the coast, and their arrival from elsewhere. It is quite clear that the dry season here is a mighty factor against the mosquito and a most encouraging ally of his enemies. It was very noticeable at Lagos this year how the first shower of rain that fell brought at once on the scene a considerable number of mosquitoes where none were present before, just as if they had been unable to go abroad without something to revive them.

Doubtless it is in a great measure due to the long-continued absence of rain, and to the nature of the soil, that there is so little fever in many inland towns. The chiefs of some of them wish to make out that they have no fever at all. Others admit that they lose children by it. It is intended that the Medical Department should make a sufficient number of observations on children at those places to determine how far they are free from, or suffer from, fever. A European town would probably have much more on the sites of these native settlements on account of the freer use of water. The chiefs of these inland towns unanimously state that they have no "black-water fever" there.

With the sanction of the Secretary of State the measures being taken to improve the sanitary condition of the town are being applied as far as practicable to the railway. "Burrow pits" near all stations are being filled up, or kerosene is used on them. The mosquito netting is to be employed there as in other quarters. Certain buildings have to be shifted. But there is nothing peculiar in this. In the dry season mosquitoes will all but disappear on the railway with reasonable attention to drainage.

In the matter of large trees, of which there are not a few in Lagos, a compromise has been adopted. It did not appear desirable to deprive the Lagos subsoil, which is made up of sand and mud, of the great pumping power that must be exercised by the many large-crowned trees now growing here. On the other hand, these trees

did afford shelter to many mosquitoes. They have been thinned out, all undergrowth has been cut away, and all the lower branches that could be lopped off without disfiguring the tree have been removed to allow free passage to the sea breeze which generally blows at Lagos.

It is painfully apparent that what is being done at Lagos against malaria is far short of what is required, but it is a beginning, and if these measures are continued for even two or three years the effect will begin to be felt to such an extent as to encourage their continuance, let it be hoped, on a greater scale.

Malarial fever is not the only disease that creates a great mortality here. Large expenditure has to be incurred with special reference to dysentery for instance. The total sum set apart for sanitary and health purposes in this colony during the current year is not under £34,500, or about one-seventh part of the whole revenue. More cannot be done without deranging other parts of the administrative machinery, which in turn would stop sanitation.

[After Sir William MacGregor's paper was read copies of lectures which had been delivered to the general public in Lagos were passed round.]

Anti-Malarial Measures in Staten Island, by Dr. DOTY, Health Officer of the Port of New York.*

Dr. DOTY selected a district known by the local practitioners to contain many cases of malaria, both acute and chronic. This section, consisting of a basin less than a square mile in extent, within whose boundaries were some twenty-five stagnant pools varying from five feet in diameter to an acre or more in area, contained not more than a hundred small wooden houses, some distance apart. A house-to-house inspection showed that at least 30 per cent. of the inhabitants were suffering from the acute or chronic form of malarial fever. In almost every house or yard were found typical breeding places for mosquitoes, either in the shape of rain barrels, cisterns, and cesspools, or of abandoned receptacles thrown about the premises. Samples of water from these, as well as all stagnant pools, were examined, and larvæ in large quantities were found. Large tubes were distributed

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British Medical Journal, 1901, vol. II., page 645.

among the houses for the purpose of collecting some of the mosquitoes infecting the neighbourhood, and among the latter the *Anopheles* were found. On two evenings live mosquitoes were secured from one of the bedrooms of a house in which there were five malarial subjects. On the first night five were taken, and all but one were of the *Anopheles* species. On the second night twenty-two were collected, and of these more than one-half were the malarial insect. In a drop of blood taken from a child seven years old suffering from acute malaria, who lived in a house on the opposite corner, a bacteriological examination showed the presence of the malarial parasite.

The mosquitoes were placed in large glass jars for observation. Many eggs have already been laid, and the laboratory work, when completed, will be published. Many tests have been made to ascertain the value of different agents in the destruction of mosquito larvæ. A solution of bichloride of mercury (1 to 2,000), sufficiently strong to kill all micro-organisms, affected the larvæ slowly, some being alive after twenty-four hours. In weaker solutions they lived indefinitely. It would, therefore, be unsafe to use this agent in ponds, etc., and the same might be said of carbolic acid and other agents experimented with. Potassium permanganate produced but little effect except in very strong solutions. During these tests the marked superiority of petroleum oil soon became manifest, and there seemed to be no special advantage of one petroleum product over another. The Lima oil which was used in petrolising the stagnant pools and rain barrels, etc., is a crude petroleum with a minimum amount of naphtha. One cubic centimetre of this added to 3,500 c. cm. of water containing larvæ killed them in three or four hours. This is equivalent to about twenty drops of oil to a gallon of water; and, as a matter of fact, this result was usually obtained by less than this amount of oil. Dr. DOTY is inclined to believe that the death of the larvæ is due to obstruction of respiration, and also that emanation from the oil or its odours, or both, is particularly repugnant, if not dangerous, to the full-grown mosquito.

There is no doubt, he says, that the best effect of the oil is gained by introducing it to a considerable depth under the water. In this way it is more surely brought in direct contact with the larvæ, particularly if the water is agitated. In petrolising stagnant pools it soon became evident that the long grass and weeds, particularly in the immediate vicinity of these places, were the abiding places of the mosquito during the day. Special attention was therefore given to the

removal of this growth, the ground being afterwards petrolised with an ordinary sprinkling pot. The cisterns, rain barrels, and other such breeding places were treated by sprinkling the inside of the woodwork and the surface of the water with oil. If the boundaries of the section experimented upon included all the breeding places in this part of Staten Island, there is no doubt that a marked diminution in the number of mosquitoes would have been apparent at once; but, unfortunately, many breeding places exist in the territory surrounding this place. Nevertheless, the opinion expressed by the inhabitants of the section indicates that there has been a positive change for the better. Dr. DOTY thinks that this investigation has been of scientific value because it has shown (1) the intimate relation between the mosquito and malarial fever; (2) the true breeding places of the mosquito; and (3) that petroleum oil will surely and promptly destroy mosquito larvæ, and, so far as careful experiments indicate, it is the only agent which can be depended upon for this purpose. The suggestion that birds, dragon-flies, etc., should be propagated for the purpose of destroying mosquitoes is, in his opinion, not entitled to serious consideration. He feels himself justified in saying that the continued presence of mosquitoes in large numbers as a rule indicates defective drainage, or in some other way an insanitary condition of the infested section, and that the radical and scientific treatment of this condition is proper drainage and a compliance with modern sanitary regulations. Any other treatment is proper only when these measures cannot be enforced, and it is under the latter conditions that the use of petroleum is indicated. The responsibility of carrying out this important work must rest with the Municipal, State, and Federal authorities. Municipal sanitary codes should include strict regulations, not only against the existence of stagnant pools, but of all forms of breeding places, and should empower sanitary officers to employ such means as are necessary to protect the public against these insects; and, when required, the application of oil should be made under their direction. In order to make this work uniform and effective the co-operation of the State and Federal authorities is absolutely necessary, and such action would, Dr. DOTY thinks, be followed by the most gratifying results.

Some Further Work on the Mosquito-Malaria Theory, with Special Reference to Conditions Around New York, by WILLIAM N. BERKELEY, A.B., M.D.*

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As a fair example of what may be locally accomplished I cite a small outbreak of malaria in a suburban New York town last summer. In August I was requested by one of the resident physicians to go there, examine the ground, and advise means of prevention. The conditions were briefly these:—

Around a large pond in the vicinity of the town four or five fresh cases of malaria had recently developed. The first case was that of a coachman who had caught malaria elsewhere and had relapsed. From his quarters, in a long row of stables at one side of the pond, the infection had passed along to other stablemen and servants on the same side to the distance of a quarter of a mile from the original site. A quarter of a mile in another direction across the pond one other case appeared in a small child. *A. quadrimaculatus* was fairly abundant in every bedroom in that area in which a proper search was made. The breeding places seemed to be segregated pools at the edge of the pond (the pond itself contained fish), and post-holes, and excavations. These last were numerous, as many buildings were going up.

The following practical measures were recommended:—(1) Extermination, as far as possible, by a party of men sent out for the purpose, of all *Anopheles* found in houses, and systematic introduction of screens in windows and doors. (2) Filling in of the smaller breeding places, and drainage of the pond. (3) Continuous seclusion of every malarial patient, by netting or otherwise, from the bite of mosquitoes while he had germs in the capillary blood; if possible, the sending away of the cachectic cases till danger of relapse was certainly passed.

These measures were intelligently put into operation at once; and the results were as prompt as they were gratifying. Not a single new local case of malaria developed. *Anopheles* disappeared

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* *Medical Record*, New York, 26th January, 1901.

promptly from houses where it had been previously a night terror, and *Culex* was greatly diminished in numbers. The local authorities expect during the coming spring to carry out the same measures even more rigidly, and believe that both mosquitoes and malaria will entirely disappear there.

Vital Statistics of Havana, Guanabacoa, and Regla, by Major W. C. GORGAS, Surgeon U. S. Army, Chief Sanitary Officer. April, 1901.

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The condition of the city with regard to yellow fever is most encouraging. It will be seen from the body of the report, that for the month we have had two cases of yellow fever and no deaths. This is the smallest April report of which we have any record. We went from the 8th March to April 20th with no cases, a period of 43 days. In 1900 the longest period was from March 26th to April 1st, both inclusive, 7 days. As the population, subject to yellow fever, is considerably larger now than at that time, I think this indication very favourable. I think it also indicates that the measures recently inaugurated, with regard to killing mosquitoes in and about the infected area, are having good results.

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The amount of sanitary work continues large. We are not now doing as much cleaning of houses with our own force as formerly; I have transferred about two-thirds of these men to the mosquito brigades. They are employed in cleaning out the various ditches and streams where stagnant water is found, and putting kerosene oil in all of these places. During the month about 20,000 houses have been gone over in this manner. A little oil is placed in every receptacle containing standing water and about an ounce into every closet and sink in the houses having water connections. Nearly every house in Havana has a cesspool, and these cesspools are ideal breeding places for mosquitoes. The oil in this way runs into the cesspool and kills the larvæ. I have recently examined several of the main sewers that empty into the bay, and have seen a large number of larvæ floating out, showing that a considerable number are being killed by this method.

May, 1901.

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But what I think most important to us is, the unusually favourable showing made by the city this year, as to yellow fever. We commence June with the city free from yellow fever, no cases being on hand. This is probably the first time Havana has ever entered June free from yellow fever. April and May also commenced in the same way.

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I cannot but hope that this exceptionally good condition is in great part due to the large amount of labour and money we are expending, in the destruction of mosquitoes; and the circumstances of the case point in the same direction.

Since March 8th, outbreaks of yellow fever have occurred twice. The first time, April 21st and 22nd, we had two cases; and again on May 6th and 7th, four cases. Each time the infected houses and three or four contiguous houses, on every side of the infected house, were carefully gone over. Every room in each of these houses was closed and sealed, and insect powder burned in them at the rate of 1 pound to 1,000 cubic feet. All standing water was drained away, where possible, and oiled where it could not be drained. The results look as if the focus of infection, at that particular point, had been eradicated. In the case of the patient taken sick March 8th after our disinfection, we went 42 days till the next case. Then an outbreak occurred, April 21st and 22nd. We again disinfected; and went 15 days till the next cases, May 6th and 7th. We again disinfected, and have gone 24 days without a case. I am more particularly impressed by these figures, as we commenced our systematic destruction about the middle of February.

Formerly we paid no particular attention to the mosquito, merely disinfecting for yellow fever, as we do for other infectious diseases. The only part of the process that killed the mosquito, was the formaline used in one or two infected rooms.

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The amount of sanitary work done continues large; but most of our attention now is paid to the destruction of mosquitoes. The suburbs, and all the small streams in the suburbs, have been pretty thoroughly cleaned out; and pools oiled and drained.

The Mayor has issued an order prohibiting the keeping of standing water, anywhere within the city limits, unless made mosquito-proof. This is being enforced; and all standing water found not protected as required is emptied, and the owner fined.

We are employing about 75 men in this mosquito work, and have gotten over the whole city during the last month; and I expect to do this every month during the summer; at any rate, as long as it seems to have the present happy result. In this way, during the past month, we have used about 1,400 gallons of oil.

June, 1901.

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The last death from yellow fever occurred on March 16th, three and a half months ago.

While we cannot say with any certainty that we will not have a recurrence of this disease before the year is over, we can say pretty positively that the excellent present conditions must be due to something that we are now doing which we have not done in past years.

Commencing about the middle of February of this year, we based our whole management of yellow fever upon the supposition that the mosquito is the medium of its transmission from person to person, the theory originally brought forward and elaborated by Dr. CHARLES FINLAY, of Havana, and finally entirely established by the beautiful and complete experiments of the Yellow Fever Commission, of which Major WALTER REED was President.

When the results of these experiments were made known, the Military Governor, General LEONARD WOOD, directed that every effort be made to carry out disinfection on the lines indicated by this discovery, and the result of four months' work has been to strengthen the conclusions reached by the Board.

The year 1901 opened up as usual, the yellow fever continuing from 1900. In January we had 23 cases and 7 deaths; in February, 8 cases and 5 deaths. On February 16th an order was issued adopting the new methods of disinfection for yellow fever.

After this date we had new cases on February 22nd, 23rd, and 27th, and on March 2nd and 8th. We then had no cases until April 20th and 21st, when two occurred, and again no more fever until May 6th and 7th, when there were four cases. Since May 7th there have been no other cases of yellow fever.

There have been years in which there was very little yellow fever

in the city during the three months under consideration, but none in which it has entirely disappeared as at present.

The years 1898 and 1899 are the two previous years in which the fewest number of cases occurred during these three months; but the great difference detween this year, for instance, and other years is that we have been for long periods—and are now—entirely free from fever.

In 1899 this was not the case. After May 7th the city was never free from this disease, showing that the infection was never entirely gotten rid of.

Since May 16th, a period of one month and a half, the city has been entirely free from fever, the last case having become convalescent on that date.

I select 1899 as the very best of the preceding years; if we consider any other year, the comparison is much more marked in favour of the present year.

From these facts, it seems to me a fair inference that our method of disinfection killed off infected mosquitoes, and that by March 8th we had rid the city of infection.

The city was then free of fever until April 20th. On the 20th a focus of infection again developed; disinfection apparently killed off any infected mosquitoes, as the city was free from fever until May 6th, when another focus developed. Disinfection again apparently killed all infected mosquitoes, and no other focus of infection has developed since this time, now nearly two months ago.

During the past three months yellow fever has been introduced into Havana from the outside three different times: once from Tampico, once from an Army Transport which had visited several coast ports, and once from an interior town. The two cases from the shipping were promptly recognised by Dr. A. H. GLENNAN, Chief of the Marine Hospital Service, and turned over to the Sanitary Department.

The third case came in from Santiago de las Vegas, and went to one of the large private hospitals.

From these facts I think we have cause for the belief that, by pursuing present methods, not only can we rid Havana of yellow fever, but that its spread may be prevented, even when introduced from the outside. This should be the ideal in all sanitary measures; and if this condition can be brought about most of the restrictions now imposed upon commerce by quarantine can be done away with.

September, 1901.

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The health conditions are decidedly the best ever attained, in any month, for this city. The least number of deaths occurring in any previous September, since 1889, was 496 in 1899; the greatest number, 2,397, in 1898; average, 877.45. For September, 1901, there were 339 deaths.

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It will be seen with regard to yellow fever that, for the month of September during the past eleven years, the least number of deaths occurred in the year 1899, when there were 18 deaths; the greatest number in the year 1896, when there were 166 deaths; average, 70 deaths. This year we have had 2 deaths.

Taking the yellow fever year as commencing April 1st, and considering the record of the past eleven years, it is seen that, for the six months up to the 1st of October, the smallest number of deaths from this disease occurred in the year 1899, when there were 36 deaths; the greatest number in 1897, when there were 659 deaths; average, 296 deaths. This year, during the same period, there have been 5 deaths.

The small number of deaths during the past month has been quite a gratifying surprise, and is difficult to account for at first glance; but when one comes to look into the statistics the reasons are evident. This year, since the 1st of March, we have had 100 men daily engaged in killing mosquitoes in every way we knew how. The result is, that, instead of having 52 deaths from yellow fever and 32 from malarial fever, we have had 2 deaths from yellow fever and 11 from malarial fever—a difference of 71 deaths under these two heads in favour of this year.

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The constant house-to-house inspection has enabled this Department to force the people to keep the interior of the houses in good condition. They have made great improvements in this respect since last September.

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Further remark is unnecessary. As to yellow fever, there has never been an approximation to this condition at any time in the last 150 years. This is the first year, during that period, in which we

have known that yellow fever was conveyed by the mosquito ; and during February the Military Governor directed that our disinfection be carried out on these lines. I attribute our very surprising results to this fact.

As each month passes we feel more and more confident that the problem of the control of yellow fever has been solved by the discovery that the mosquito is its conveyor ; and little anxiety is now felt when a focus develops in this city. From repeated successes in the last six months we believe that, with present disinfection methods, any infection from yellow fever that may be introduced into the city can be stamped out.

First Progress Report of the Campaign against Mosquitoes in Sierra Leone, by RONALD ROSS, F.R.C.S., D.P.H., F.R.S. Dated Liverpool, 15th October, 1901.

PRELIMINARY.

This enterprise was undertaken in the following circumstances :— Shortly after the development of the parasites of malaria in mosquitoes had been determined by my researches of 1895–98, I suggested that the proper way to extirpate malaria in towns and cantonments would be to drain the breeding places of the insects which carry the disease. All efforts to induce the authorities to adopt this idea remained, however, almost entirely unavailing during two years ;* and at last I resolved upon starting the work by the help of private enterprise. On the 1st of May, 1901, I received from a gentleman with whom I have the honour to be acquainted the sum of one thousand pounds with which to commence the work ; and this amount he has since doubled. The project was adopted with energy by the

* The admirable measures instituted against malaria in Lagos by Sir W. MACGREGOR and Dr. STRACHAN are conducted largely on different lines ; and the operations of YOUNG and THOMSON in Hong Kong, and of others elsewhere, have been very limited in area. I shall presently refer to the work in Havana.
Original Note.

Liverpool School of Tropical Medicine ; and supplementary gifts and assistance of all kinds were given by ALFRED L. JONES, Esq., J.P., JOHN HOLT, Esq., F. SWANZY, Esq., Professor BOYCE, MAX MUSPRATT, Esq., Dr. KOHN, and other gentlemen. Mr. LOGAN TAYLOR, M.B., B.S., of the Pathological Laboratory of Glasgow University, was appointed to superintend the operations ; and Freetown, Sierra Leone, was selected to be the site of the experiment, partly because its malaria had been already surveyed by the scientific expeditions of the Liverpool School of Tropical Medicine and the Royal Society, and partly because the place is so difficult to deal with on account of the heavy rainfall and the nature of the soil that it affords a fair, and, indeed, somewhat severe test, of the feasibility of the measures recommended by me. As showing the popular interest in the matter, I may mention that the expedition was entertained by Mr. ALFRED L. JONES at a valedictory banquet, which was honoured by the presence of the Lord Mayor of Liverpool, the Lord Bishop of Liverpool, the Director General of the Indian Medical Service (Surgeon-General HARVEY, D.S.O., C.B.), the President of the Royal Institute of Public Health (W. R. SMITH, Esq., M.D., F.R.S.E.), and other distinguished guests. The Right Honourable Mr. JOSEPH CHAMBERLAIN, H.M., Secretary of State for the Colonies, signified his approval and support of the scheme, and the expedition left England on the 15th of June.

COMMENCEMENT OF CAMPAIGN.

We arrived at Freetown * on the 2nd of July, and were very hospitably entertained by His Excellency the Governor, Sir CHARLES KING HARMAN, K.C.M.G. At a public lecture, at which His Excellency presided, a resolution in support of our efforts was unanimously adopted.

Dr. LOGAN TAYLOR commenced work without delay. In my first suggestions for controlling malaria I had recommended measures against mosquitoes of the genus *Anopheles* only ; but mosquitoes of the genus *Stegomyia* have now been conclusively proved to carry yellow fever ; and mosquitoes of the genus *Culex* have long been known to carry *Filaria nocturna* (elephantiasis). Malaria and elephantiasis prevail all down the coast ; and many medical men of

* Freetown contains 30,000 inhabitants.

repute consider that yellow fever also has existed there from time to time. In addition, it is beginning to be thought by some that mosquitoes may carry other diseases, especially various tropical fevers distinct from malaria and typhoid; and, altogether apart from their pathological agency, most kinds of mosquitoes undoubtedly cause an immense amount of annoyance in the tropics, and, next to the heat, constitute perhaps the principal drawback of life in warm climates. We determined, therefore, to push our campaign against all kinds of mosquitoes indiscriminately.

Dr. TAYLOR immediately engaged the services of over twenty men, under intelligent head men. To these His Excellency the Governor added twelve men, and gave the necessary carts and implements. This force was divided into two gangs; a small gang of six men (called the *Culex* gang), to collect from private houses all the broken bottles and buckets, empty tins, old calabashes, and similar unconsidered vessels in which mosquitoes of the genera *Stegomyia* and *Culex* breed: and a larger gang (called the *Anopheles* gang), to drain the pools and puddles in the streets and the backyards of the houses, in which *Anopheles* breed.

PROGRESS OF CAMPAIGN.

The *Culex* gang, under a native head man, did very rapid work. They piled the rubbish into carts, which then discharged it into an assigned rubbish shoot. At the same time they showed the larvæ to occupants of houses and instructed them in the manner of destroying them by emptying the vessels which contained them, or by dropping a little oil on the surface of water in which they live. It was found that on the average this gang cleared about fifty houses, and removed about ten cart-loads of empty tins and broken bottles daily. The effect of this work on the prevalence of *Culex* and *Stegomyia* can be imagined when it is remembered that about one-third of the tins and bottles contained the larvæ at this season (the rains). Every house had previously been breeding mosquitoes in its own backyard or garden. The occupants welcomed the gang wherever it went, and some stated that they had not been able to get rid of their rubbish for years.

The *Anopheles* gang had a more difficult task. The breeding pools of these insects in Freetown, both in the rains and the dry weather, have been minutely described by two previous scientific

expeditions.* At this season the water courses contained impetuous torrents too rapid for larvæ to live in; but the streets, yards, and gardens possessed numerous pools of rain-water, well suited for them. These were attacked by many methods. Some were filled with earth, rubble, and turf. Others were evacuated by cutting through the rock which contained them, or by making channels in the soft earth. Owing to the large rainfall, (estimated at about one hundred and sixty inches annually), to the peculiar nature of the ground, and to the very defective surface drains, these puddles were exceptionally numerous in Freetown; and, in order to drain many of them as soon as possible, it was deemed advisable to adopt the simplest and least expensive methods at first, and to reserve more permanent works for the future. At the same time several men were specially employed in brushing out with brooms, or treating with crude petroleum or creosote, those puddles which the workmen had not yet had time to touch. Progress was fairly rapid in spite of the deluge of rain; and many of the worst streets were fairly well drained in a few weeks.

On the 22nd of July, I left Sierra Leone in order to visit Lagos and the Gold Coast. A few days later Lieutenant MCKENDRICK, M.B., of the Indian Medical Service, arrived. The government of India, to whose well-advised action in 1898 so much is due, had determined, on the initiative of Surgeon-General HARVEY, to send Lieutenant MCKENDRICK to study our operations in Freetown. Dr. MCKENDRICK remained there for a month.

I returned to Sierra Leone on the 16th of August, and, after witnessing Dr. TAYLOR'S excellent work, left after five days, in company with Dr. MCKENDRICK for England, on private affairs. Shortly after my departure Dr. DANIELS, Superintendent of the London School of Tropical Medicine (conveyed by the Liverpool School), arrived on the same errand as Lieutenant MCKENDRICK. He also remained some weeks with Dr. TAYLOR, and studied his methods with great care. His report on the subject will be given at the end of this report.

In letters dated the 17th and 28th September, Dr. TAYLOR says that progress has been satisfactory, although impeded by heavy rain. The *Culex* gang had cleared 6,500 houses up to the former date, and, I calculate, must have removed more than a thousand cart-

* Report of the Liverpool Malaria Expedition to Sierra Leone, University Press, Liverpool, 1900; and Reports of the Malaria Committee of the Royal Society, Harrison and Sons, St. Martin's Lane, London.

loads of rubbish. The total number of workmen employed, including the twelve lent by the Governor, now number fifty-three. His Excellency has also given Dr. TAYLOR the assistance of Dr. BERKELEY, of the Colonial Medical Service, who had previously done much useful work in Freetown in this connection. Major SMITH, the able head of the Royal Army Medical Corps in Sierra Leone, is taking active steps to expel mosquitoes from the various military barracks. Drs. DANIELS and TAYLOR have been able to inspect several places at a distance from Freetown, with a view to starting work there also. Two men are specially employed in keeping the centre of the town free from mosquitoes, while the *Culex* gang is working elsewhere; but as this gang had cleared nine-tenths of the town up to the 28th September, it will now be able to commence at the centre again, and perfect its former work.

As the rains are now ceasing, the dry-weather operations will shortly begin. These will consist chiefly in attacking the drying water courses, in which *Anopheles* chiefly breed at that season. Dr. TAYLOR is already beginning the work from the 1st October, by filling hollows in rocks with concrete. These operations will be detailed in a future progress report. It is possible that a hundred or more men will have to be employed shortly.

RESULTS UP TO THE PRESENT.

It is always very difficult to make an exact estimate of the number of mosquitoes anywhere, and, therefore, to gauge their increase or diminution with mathematical certainty. For the present we must rely on a general consensus of opinion. Judging from this, the results are already most encouraging—indeed, unexpectedly so. Lieut. MCKENDRICK informs me that he was not conscious of having once been bitten by mosquitoes during his month's stay in Freetown. After the first week or so, I myself was never bitten, either at Government House* or at the house of the expedition, in the centre of the town, though I am sure I should have been bitten several times a day in both, before the commencement of operations. Dr. TAYLOR writes on the 17th September, "I think there is no doubt but that the number of mosquitoes (*Anopheles*) in the streets we have dealt with is diminishing; the people

* Capt. Hodgins, A.D.C. to the Governor, had partially cleared Government House of larvæ before our arrival.

resident in the streets will tell you that at once; and the number of pots and tins that have been removed has made a considerable diminution in the *Culex*"—meaning also *Stegomyia*. On the 28th September, he writes, "The mosquitoes are still on the decline, and in the streets we have been working in it is exceedingly difficult to find *Anopheles* now. Of course in the untouched parts they are still to be got. As for the *Culex* (or *Stegomyia*, to be correct) they have got a fright. They also are getting very scarce. The true *Culex* I seldom see; only now and again." What this means in a tropical town only those who have resided in such can know.

The valuable testimony of Dr. DANIELS to the same effect is given in his report at the end. All those who are familiar with his important work on malaria and other tropical diseases will know that he is one of the most cautious and trustworthy of observers.

Altogether I think that we have reason to be more than satisfied with the progress made.

ACCOUNTS.

It might be imagined that all this work has been very expensive. On the contrary the expense has been slight. The whole cost of the expedition from its beginning, including cost of fitting out, salary of Dr. TAYLOR, wages of from twenty to forty workmen, and of eight hammock boys, rent and fitting of the house of the expedition, and other items, had amounted, at the end of September, that is for three and a half months, to only £304. This is exclusive of passages, oil, cement, and of the services of carts, and of twelve men lent by the Governor. The wages of the workmen may be put roughly at about one pound a month each. Detailed accounts have been submitted to the School Committee and to the subscribers.

OTHER EXPEDITIONS.

On passing Bathurst, and during my visit to the Gold Coast, I was able to arrange with Sir GEORGE DENTON, K.C.M.G., and Major NATHAN, C.M.G., Governor of the Gambia and the Gold Coast, to start similar work in Bathurst, and in the principal towns of the latter colony. Consequently, Dr. EVERETT DUTTON, Walter Myers Fellow, was despatched to Bathurst to make a preliminary survey of the subject there—a thing which had not yet been done; and to start some

operations against mosquitoes, with the help of the Governor, and of a sum of money from the Sierra Leone fund. As regards the Gold Coast, a handsome sum of money has been specially placed at my disposal by a philanthropical gentleman to pay the salary of a delegate; and I am happy to be able to state that Dr. BALFOUR STEWART has accepted the post. Details of these expeditions will be given in later reports.

APPENDIX.

LETTER FROM C. W. DANIELS, ESQ., M.B. CANTAB.

NOTE.—*In reading this letter it is necessary to remember that Dr. Daniels inspected the Sierra Leone operations little more than two months after they had been commenced. See also the remarks under the headings,* PROGRESS OF THE CAMPAIGN *and* RESULTS *above.*—R. ROSS.

1st October, 1901.

DEAR ROSS,

I have carefully examined the various works which have been undertaken with a view to the serious diminution in the number of mosquitoes in Freetown, Sierra Leone. The common mosquitoes found are :—*Anopheles costalis*, the carrier of malaria, and also of *Filaria nocturna*. *Stegomyia fasciata* (*Culex taeniatus*) or brindled mosquito, Calcutta, the mosquito supposed to carry yellow fever.

Two *Culices* (I think, *fatigans*, which carries *Filaria nocturna*, and another which is known both on the East Coast and Shire and Uganda Highlands, but does not attack man) were found, but not commonly.

A. funestus was found near but not in Freetown.

In my opinion, already your efforts have been crowned with a large degree of success, as there has been a noteworthy diminution in the number of the first two genera found in the houses. The number of breeding grounds has been enormously diminished.

The operations, having been only recently begun, are, of course, as yet far from complete. A considerable part of the town, perhaps half, has not been touched. Even in the parts longest under treatment, in the yards adjoining the streets, there are still numerous breeding grounds ; and in the streets themselves occasional places have either been overlooked or the works undertaken have not been effective as yet.

The breeding places dealt with could be only of importance in the peculiar circumstances of Freetown, *i.e.*, where the soil is impervious and the rainfall excessive (110 in. to 200 in.). Even in Freetown most of them would be destroyed by a week's dry weather, and some by less. As, however, the wet season in Sierra Leone is a prolonged one, for this place these breeding grounds are of great importance, and in dealing with them an excellent beginning has been made.

A great part of the work will not be permanent. The rock cuttings are too narrow, many of them being blocked after each shower. The earth cuttings are also very liable to fall in. This results in much extra work and supervision, as considerable supervision and labour is required, constantly, to keep the work already done in order.

I suggest that during the dry season the rock cuttings should be broadened, so as to be at least three inches at the bottom, the sides being inclined at about 60°. When the rush of water is greater a broader cutting will be requisite.*

The earth cuttings should in all cases have sloping sides where possible, as this minimises the liability to formation of pools, and ensures, even with a small amount of water, a persistent current. There are few things more suitable for *Anopheles* breeding grounds than a drainage system in which the water supply is insufficient to flush the drains.

The plan adopted of placing large stones at the edge of the channel, blocked behind by smaller ones, will, I think, suffice if the work is strengthened with cement; but brick drains would be preferable in my opinion, as they are easier to clear.

A large amount of work has been done by filling up rock pools with small broken stones, and, even where the traffic is great, this, when strengthened with cement, will prove to be permanent.

The work is so far incomplete that it is essential that at least one other complete wet season should be spent here. Constant European supervision is necessary, and one man is not sufficient for the purpose. There should be at least two Europeans engaged in the supervising; and a larger staff of workmen (quite twice the present) would, I think, be required, as so much of the work will require redoing, and there are other places to deal with.

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* Exact uniformity is not essential, but an approximation to it will save a large amount of labour in clearing the channels; and as this requires to be done very frequently, the point is of importance.

Towards the foot of Mount Aureole there are in places numerous springs from which the water is constantly running. Pits, usually shallow, have been dug in this district, and in these *Anopheles* larvæ are constantly found. Some of them will be difficult to deal with by cuttings alone; and the more permanent should, I think, be converted into covered wells with an overflow, underground—say two feet below the surface—leading into a drain to the nearest stream. None of these places have, as yet, been dealt with.

There is one similar place in the Grassfields District, and I feel sure that there are others both near the Wilberforce Barracks and near Kissy. The constant rains and the general waterlogged condition of the ground prevent more definite information being obtainable till there is some continued fine weather. Such places are common, and are the important ones in the hilly districts of Central Africa.

In a few of the wells, which are so numerous in many districts of Sierra Leone, *Anopheles* (*costalis*) larvæ were found in numbers. Though I do not think from previous experience that these will at any season in the year be of very great importance, still they are an additional source. In none of the broad public wells which contain fish were larvæ found, and on placing a few fish in one of the infested wells the larvæ speedily disappeared, but many of the fish died.

Covered wells in any case are safe; but to so repair the numerous broken-down wells and provide them with covers would be costly and uncertain, as the covers would not be used in many cases.

I am informed that there would be serious difficulty in closing these private wells, and in substituting for them a smaller number of public ones, but that when a good town water supply is obtained much could be done in this direction. Such a water supply, it is expected, will be shortly sanctioned.

Equally dangerous are the numerous pits remaining from disused latrines. Those in use (in many cases overflowing) are dangerous for other reasons, but not as breeding grounds for *Anopheles*.

There are a few deep pools which probably contain water during the greater part of the dry season, and which harbour *Anopheles* larvæ; these require to be filled up.

I notice that some pits are being filled with the mixed assortment of tins and bottles removed from houses. Broken bottles, or others, are well adapted for filling in pits, but the use of tins is to be avoided, as the ground will certainly fall in. On these, as on other points, the practical experience of the details gained by Dr. TAYLOR will be

invaluable in the next wet season. Opposite houses, I think, some bridging of gutters should be done, as otherwise the edges of the gutters are bound to fill in.

* * * * * *

Though I consider that you have already proved the practicability of exterminating *Anopheles* in Sierra Leone during the wet season, the work is at present incomplete, even in the streets in which most work has been done; and, I estimate, at the present rate of work, will still be incomplete at the end of the wet season, when the work will be entirely changed. During the dry season, in addition to dealing with the new conditions which will then arise, the work already done should be placed on a permanent footing.

In the next wet season double the men, say one hundred, should be employed, and two Europeans for supervision. One European, even so able and energetic a man as Dr. LOGAN TAYLOR, barely suffices for thorough supervision of the present work.

I am aware that this will cost, apart from the expense of supervision, over £100 a month instead of the £50 to £60 which, including the cost of labour provided locally, is now spent; but it will be better for one place to be done well, and that a difficult one to deal with, than that partial measures be attempted in many places.

The experiment is being so closely watched and criticised, that failure, or only doubtful success, would be a disaster.

I think, therefore, that it will be more to the true interests of West African hygiene for attention and money to be concentrated on Sierra Leone.*

* * * * * *

I think it would be advisable to attempt to obtain in Sierra Leone some numerical estimate of the present prevalence of malaria, and for this purpose suggest as the most convenient the estimation of the proportion of children with splenic enlargement at fixed ages, say between one and two years of age, as, up to two or three years, reliable statements as to the age of children can generally be obtained. As a check on this method, Barbadians in the West India regiment who have not been previously exposed to malaria, and consequently are highly susceptible, should be examined. In them malarial infection is indicated by malarial fever. The length of residence in Sierra

* There is no fear that our efforts will be abandoned before we have done as much as we conceive it our duty to do.—*Original Note.*

Leone requisite for malarial infection in the Barbadians will then give an indication of the present liability to infection.*

In conclusion, I wish to express my thanks to you personally, and to the Liverpool School of Tropical Medicine, for the opportunity afforded me of seeing the first real British practical application of the principles you have elucidated.

I am,

Yours very sincerely,

C. W. DANIELS, M.B.,

London School of Tropical Medicine.

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* In order to guard against misapprehension, it is advisable to state here that we are not now undertaking to prove over again that mosquitoes carry malaria. This fact was fully established long ago. Our present intention is simply to give an object lesson in the manner of ridding tropical towns of mosquitoes by drainage and cleaning up. We are prepared to spend a large sum of money for this purpose; but we are not prepared to continue the work for ever. The work—especially the drainage and collection of rubbish—properly belongs to the local authorities. If they choose to continue our efforts, then we can confidently promise that the mosquito-borne disease in Freetown will be, ultimately, very materially reduced. If, however, they discontinue them—if they allow the town to sink back into the condition it was in when we arrived—then I can only say that the mosquito-borne disease will remain. It is for them to choose. I may add, however, that I have no doubt that the former course will be the one adopted.

Original Note.

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On Yellow Fever and Mosquitoes.

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* The reader must be warned that the historical passages in many of the Italian works are largely apocryphal. The works of B. GRASSI of Rome are especially bad in this respect, and should not, I think, be included in any list of honest scientific books; I have therefore omitted them from this bibliography.—R. ROSS.

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NOTE.—Succeeding parts of this Memoir will contain descriptions of the further progress of the campaign in Sierra Leone and elsewhere.

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